

REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including the Report of the Imperial Cotton Specialist)

1912-13



CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1914

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Report of the Agricultural Research Institute and College, Pusa,

(Including the Report of the Imperial Cotton Specialist)

1912-13.

REPORT OF THE DIRECTOR

(JAMES MACKENNA, M.A., I.C.S.)

I.—CHARGE AND STAFF.

Charge.—Mr. Bernard Coventry, who was, on the 14th June 1912, appointed a Companion of the Most Eminent Order of the Indian Empire, held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to the 6th March 1913, when he proceeded on ten months' combined leave, and I was appointed to officiate for him.

Mr. A. C. Dobbs, Assistant to the Agricultural Adviser to the Government of India, returned on the 4th November 1912 from the six months' combined leave granted to him.

Staff.—The Chemical Section remained in charge of Dr. J. Walter Leather, V.D., Ph.D., F.I.C., throughout the year.

Mr. H. E. Annett, B.Sc., M.S.E.A.C., F.C.S., Supernumerary Agricultural Chemist, continued to officiate as Agricultural Chemist, Punjab, until 13th November 1912, when he proceeded on two months and 15 days' privilege leave combined with study leave for ten months and four days. The study leave was granted to enable him to

take a course in Biological Chemistry at Cambridge University or some other institution and visit Agricultural Experiment Stations in England and Germany in order to keep in touch with the most recent work, and incidentally to improve his knowledge of German.

Mr. A. Howard, M.A., A.R.C.S., F.L.S., held charge of the Botanical Section up to the 28th April 1913, when he proceeded on six months' combined leave. Mrs. Howard, M.A., his Personal Assistant, accompanied him. From 8th May to 26th September 1912, Mr. and Mrs. Howard were, as in the previous two years, at Quetta in connection with the development of the Fruit Industry in Baluchistan, an arrangement the continuation of which for a further period of three years (*i.e.*, up to the end of 1916) has been sanctioned by the Secretary of State for India. During their absence, the Second Assistant of the section has held charge of current duties at Pusa and the Third Assistant of the current duties at Quetta. During the year under report, Mrs. Howard was awarded the *Kaisar-i-Hind* Medal of the First Class for public service in India.

Dr. E. J. Butler, M.B., F.L.S., resumed charge of the Mycological Section on his return from privilege leave on July 7th, 1912.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., F.L.S., Supernumerary Mycologist, was transferred to Coimbatore on April 21st, 1913, to act as Government Mycologist. Madras.

The Entomological Section was in charge of Mr. A. J. Grove, M.Sc., Supernumerary Entomologist, till 29th July 1912, when Mr. H. Maxwell-Lefroy, the Imperial Entomologist, returned from leave. Mr. Lefroy, however, resigned his post on the 30th November 1912 and Mr. Grove was appointed to officiate as Imperial Entomologist. Mr. T. Bainbrigge Fletcher, R.N., F.E.S., Entomologist to the Government of Madras, has been nominated for appointment as Imperial Entomologist. He will take up his duties at Pusa as soon as his successor arrives in Madras.

Mr. F. M. Howlett, B.A., F.E.S., continued in charge of the Pathological Entomological Section throughout the year except for a month and a half in September and October 1912 when he was on privilege leave.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson, B.A., throughout the year excepting three weeks in September-October 1912, when he was on privilege leave.

Mr. J. Hugh Walton, B.A., B.Sc., joined the staff as Supernumerary Agricultural Bacteriologist on 25th October 1912.

The Agricultural Section continued in charge of Mr. S. Milligan, M.A., B.Sc., throughout the year with the exception of one month in September 1912, when he was on privilege leave.

None of the Supernumerary Agriculturists worked at Pusa; Mr. G. D. Mehta, L.Ag., B.A., N.D.A., N.D.D., was under training in the Central Provinces; Mr. N. S. McGowan, Dip. in Agric. (Cantab.), continued to act as Deputy Director of Agriculture, Bihar and Orissa; and Mr. T. Gilbert, B.A., Dip. in Agric. (Cantab.), has been working under the Bombay Government.

II.—WORK OF THE INSTITUTE.

Scientific Work.—An account of the scientific work of the Institute during the year is given in the reports of the several sections.

Training.—The training of students on the lines laid down in the Prospectus was continued, and short courses were also given in Cattle management, Sericulture and Lac culture.

During the year under report, five students were under training in Agricultural Chemistry. Of these one Government stipendiary deputed by the Bengal Department of Agriculture, and one private student from the Central Provinces resigned. One Government student deputed by the Agricultural Department of Bihar and Orissa was

recalled for duty at the Agricultural College, Sabour, before the completion of his course. The remaining two students (a Government stipendiary from the Travancore State and a private student from Madras) continued their course.

A private student from Madras was admitted to the post-graduate course in Economic Botany on 1st October 1912.

The Entomological and Mycological collector deputed by the Agricultural Department of Bihar and Orissa, and referred to in last year's report, was under training in the Mycological Section until August 17th, 1912, when his course was terminated as he was found unfit for further training.

In the Entomological Section, the student deputed by the Department of Agriculture, Travancore, continued his training, and a student deputed by the Assam Department of Agriculture was admitted on November 1st, 1912, to the post-graduate course. An Agricultural Assistant of the School of Agriculture, Giza, deputed by the Egyptian Government, was given three months' training in practical Entomology.

Besides the regular students mentioned above, the following visitors to the Institute worked in the Entomological Laboratory during the year :—

Dr. L. H. Gough, Entomologist to the Department of Agriculture, Egypt, in September 1912, in connection with the boll-worm parasite.

Mr. A. Alfieri of the Khedivial Agricultural Society of Cairo from July to September 1912, in connection with the boll-worm parasite.

Lala Bishember Das, Assistant Professor of Biology, Government College, Lahore, from October to December 1912.

Lala Madan Mohan Lal, Assistant Professor of Entomology, Agricultural College, Lyallpur, for three weeks during October 1912.

The Entomological Assistant of Baroda came to Pusa in April 1913 to discuss the programme of his work for the ensuing year. The Weaving Expert to the Government of Bengal and the Principal of the Weaving School, Benares, inspected the work of the Silk-House at Pusa.

A course of instruction in identification, breeding and general observation of *Stegomyia* was given by the Imperial Pathological Entomologist in July 1912 to Medical Officers engaged in the "Stegomyia Survey."

A probationary research Assistant under the Agricultural Chemist to the Punjab Government was deputed to this Institute to undergo training for one year in Bacteriological methods. He joined the Bacteriological Section on 13th August 1912.

As the existence of facilities at Pusa for post-graduate study becomes known, there is a steadily increasing number of enquiries concerning them, and towards the end of the year under report several applications for admission were received from private students. Every encouragement is given to such students, and it is hoped that the thorough training they can obtain at Pusa will enable them, on leaving, to secure remunerative employment in the special lines they have taken.

During the year under report, 19 students attended the short courses—three in "Cattle management," nine in "Sericulture" and seven in "Lac cultivation." Most of these students came from the Native States of Travancore, Bhopal, Karauli and Mysore.

III.—PUBLICATIONS.

Publications.—The issue of the Journal, Memoirs and Bulletins was continued. The demand for the Journal and Bulletins, which deal in a popular way with matters of practical interest, is steadily increasing. The Department published, during the year, 19 Memoirs and 5 Bulletins; against 14 Memoirs and 4 Bulletins in the previous year. The Provincial Departments continue to

supply an increasing number of contributions for these publications.

The first bacteriological memoir was published during the year, the section having been comparatively recently organised.

A Veterinary Series was added to the scientific memoirs of this Department during the year under review, and three issues were published during the year. Two more are in the press. This series of memoirs is open to receive papers from all members of the Civil Veterinary Department and other workers in Veterinary Science in India. It has also been decided to publish as Bulletins of this Institute, veterinary papers which are unsuited for publication in the Agricultural Journal of India or in the veterinary series of scientific memoirs. One such was published as Bulletin No. 32.

The Government of India have sanctioned a permanent annual grant of Rs. 29,000 for the agricultural and veterinary publications issued by the Imperial Department of Agriculture. As a result of the expansion of departments and the greater experience on the part of the staff, the number of publications continues to increase and it has been necessary to exercise the greatest economy in connection with publications.

IV.—GENERAL ADMINISTRATION.

Buildings and Works.—During the year under report the Government of India sanctioned the construction of two additional bungalows for European officers, the extension of the library and the extension of the Director's office building. A proposal to install electric lights and fans in the European bungalows and the Guest House at Pusa, and to work the farm machinery electrically, is under consideration.

Library.—The third edition of the catalogue of the library is under preparation. The library is rapidly becoming overcrowded, and during the year over a thousand volumes have been added, besides several foreign bulletins,

memoirs, reports, etc. An ever-increasing number of agricultural publications is received in exchange from all parts of the world.

Pusa Middle English School.—In November 1912, a Government Middle English School was established within the Pusa Estate for the education of the children of the subordinate staff of the Institute. The school is also open to the public in the surrounding villages. Plans and estimates for the school building and for quarters for teachers, are under the consideration of the Government of Bihar and Orissa, and the school is at present located in temporary quarters. As the Middle English School does not meet the requirements of the staff at Pusa, proposals have been submitted to the Government of India for raising the present school to the status of a High School and also for the establishment of a Girls' School at Pusa.

General Health of the Station.—The general health of the station during the year under report was, on the whole, very good. Medical relief was afforded to 8,538 new cases of which 8,333 were treated in the out-patients' department of the hospital and 205 were admitted as indoor patients. One hundred and eighty-three cases amongst European officers and their families were attended to. The daily average number of patients treated was 52.73 outdoor and 9.64 indoor.

Three deaths occurred in hospital, one from Debility (old age), one from Empyema and one from Malarial Cachexia.

An epidemic of cholera, which broke out in the villages in the immediate vicinity of Pusa during the months of April, May, and June, threatened to be a source of great danger. The disease entered the Estate during the earlier part of the outbreak and one man was attacked, but recovered. Immediate and successful measures were adopted, including the thorough cleaning and disinfection of all the wells on the Estate, to prevent the spread of the disease.

One hundred and forty-one surgical operations were performed, of which thirty were major, and one hundred and eleven minor.

The number of Estate cases treated for malarial fever was considerably less than during the previous year; this was most probably due to the fact that the inhabitants were more willing than heretofore to take quinine prophylactically towards the close of the monsoon.

Eleven primary vaccinations and five re-vaccinations were performed during the early part of the year.

Lieutenant-Colonel F. J. Drury, I.M.S., Inspector-General of Civil Hospitals, Bihar and Orissa, visited Pusa on the 7th December 1912 and inspected the Hospital and the medical arrangements. He has recommended the addition of a Female Ward to the Hospital, and proposals for its construction are under consideration. The Government of India have recently sanctioned the appointment of a midwife to be attached to the Hospital.

V.—ACCOUNTS.

The total expenditure during the financial year 1912-13 was Rs. 4,00,077 as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	1,43,509
Chemical Section	34,828
Mycological Section	39,650
Entomological Section	36,914
Pathological Entomological Section	26,641
Botanical Section	36,099
Bacteriological Section	23,783
Agricultural Section	58,653
TOTAL	4,00,077

The above amount of Rs. 4,00,077 included expenditure under the special grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser for special Agricultural Experiments.

The principal items of expenditure under this special grant were as under :—

	Rs.
(1) Experimental cotton cultivation conducted by the Imperial Cotton Specialist	2,000
(2) Contribution towards the pay of the Flax Expert engaged by the Bihar Planters' Association for 1912-13	2,750
(3) Purchase of special agricultural implements and machinery	2,210
(4) Saltpetre experiments carried on by the Imperial Agricultural Chemist	380
(5) Poultry Experiments at Pusa	1,210

The budget of the Agricultural Adviser also includes a grant of Rs. 1,10,000 for meeting the expenditure for three years from 1911-12 in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces for the development of the Indian Sugar Industry; and a grant of Rs. 15,000 for payment to the Indian Tea Association as a grant-in-aid.

In March last, the Government of India provisionally allotted, out of the surplus of Imperial Revenue, a sum of Rs. 60,000 for improvements connected with the Pusa Institute. This special grant will be mainly utilised for the purchase of steam cultivating machinery and labour-saving appliances, the extension of the library, the development of the fruit work at Quetta, the testing of milling and baking qualities of wheats, bacteriological investigations in connection with rice cultivation, the demonstration of improved methods of saltpetre refining, the construction of a potculture-house for mycological investigations and other minor improvements.

The gross receipts during the year by sale of farm produce, milk, and other miscellaneous articles, amounted to Rs. 14,663 as against Rs. 9,455 of the preceding year.

VI.—VISITORS.

The Hon'ble Sir Charles Stuart Bayley, K.C.S.I., I.S.O., Lieutenant-Governor of Bihar and Orissa, visited

the Institute on the 31st January 1913. His Honour took this opportunity to invest Mr. Bernard Coventry with the insignia of the "C.I.E." and to present the *Kaisar-i-Hind* Gold Medal for public service in India, to Mrs. Howard, M.A., Personal Assistant to the Imperial Economic Botanist. His Honour was accompanied by Lady Bayley and the Private Secretary, and the party included the Hon'ble Mr. E. V. Levinge, C.S.I., Member of the Board of Revenue; the Hon'ble Mr. H. LeMesurier, C.S.I., C.I.E., Chief Secretary to the Government of Bihar and Orissa; the Hon'ble Mr. F. N. Fischer, I.C.S., Commissioner, Tirhut Division; Mr. W. B. Heycock, I.C.S., Director of Agriculture, Bihar and Orissa; and Mr. A. H. Vernede, I.C.S., Collector of Darbhanga.

During the year under report the Hon'ble Sir Harcourt Butler, K.C.S.I., Member-in-Charge of the Education Department of the Government of India; Sir Krishna Gobinda Gupta, K.C.S.I., Member of the Secretary of State's Council; Mr. H. N. Ridley, C.M.G., M.A., F.R.S., F.L.S., F.R.H.S., retired Director of Gardens, Singapore, and many others, also visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST

(S. MILLIGAN, M.A., B.Sc.)

I.—ADMINISTRATION AND TOURS.

Charge.—I held charge of the section throughout the year with the exception of one month spent on privilege leave in September.

Supernumerary Establishment.—None of the Supernumerary Establishment have worked under me during the year.

Mr. G. D. Mehta, Supernumerary Agriculturist, who was on deputation under the Government of Bombay, is now under training in the Central Provinces.

Mr. N. S. McGowan, Supernumerary Agriculturist, is working as Deputy Director of Agriculture, Bihar and Orissa, from 23rd February 1912.

Mr. T. Gilbert, Supernumerary Agriculturist, is at present working under the Bombay Government.

Staff.—Mr. Judah Hyam continued in charge of the breeding herds. He was on privilege leave from 2nd January 1913 to 4th February 1913, during which period Mr. L. S. Joseph, Veterinary Assistant, acted for him.

Mr. Mohamed Ikramuddin held the post of First Farm Overseer throughout the year. He has performed his many and varied duties satisfactorily.

Mr. Mohamed Ziauddin Hyder worked as Second Farm Overseer until 15th May 1913, when he left this department on transfer to the United Provinces Agricultural Department.

Babu Kshiti Bhusan Mukerji, Senior Fieldman, left Pusa on 11th February 1913 on transfer to the Bihar and Orissa Agricultural Department.

Babu Brajraj Mukerji was promoted to the post of Senior Fieldman from 11th February 1913.

Tours.—During the year I made several short tours in Bihar and conducted the final examinations in Agriculture at Coimbatore and Lyallpur in March and April.

Training.—Three students were instructed in cattle breeding.

II.—FARM CULTIVATION.

Character of the Season.—The rainfall during the year amounted to 41·26" (*i.e.*, from 1st May 1912 to 30th April 1913) as against 53·49" last year.

Monsoon rainfall began early and continued normal up to the second week in July. The bad effects of a prolonged break during the latter half of that month were mitigated by fairly well distributed rains in August. The September and October rainfall was, however, far short of normal. Late rains in November and February, however, improved the rabi crops considerably. The season was thus unsuitable for rice, sugarcane, maize and wheat, but fairly good for such crops as *sarson*, oats, etc.

Cropping.—The present double cropping system appears to require the application of organic manures at more frequent intervals to ensure maximum yields. During the present year owing to the scarcity of rainfall in September and October no increase was obtained in the wheat crop succeeding a green manuring with sunn hemp. The manure evidently became available at too late a date to affect the grain outturn.

The following crops were grown:—Sugarcane, maize, wheat, *sarson*, *guar*, turnips, oats, gram, linseed, lucerne, paddy, *mung*, *joar*, *khesari*, oats and peas, *arhar*, Florida velvet beans, sweet potatoes, *kudzu* (a Japanese fodder), guinea grass, *bajra*, cowpeas, castor, indigo and jute.

Experimental Cultivation and Implements.—Suitable methods of sowing and inter-cultivating sugarcane and maize have been worked out. The most economical spacings for these crops are under investigation. Implements suitable for inter-cultivation are under trial. A year's experience of the heavier low-lying area has demonstrated the

great superiority of revolving harrows and sectional rollers over drag-harrows and levelling beams for dealing with this class of land.

The permanent manurial experiments have been continued.

The green manuring experiments in collaboration with the Imperial Agricultural Bacteriologist have been altered in conformity with last year's experience.

The use of crude khari salt for rice.—This salt was applied as in last year's experiments in September, but on account of the dryness of the soil had little effect.

Artificial sprouting of sugarcane.—This practice proved useful against the attacks of termites.

Fodder.—The following fodder crops have been under observation :—Guinea grass, lucerne, *kudzu*.

III.—LIVE-STOCK AND POULTRY.

Breeding Herd.—During the year 13 cows and 22 young cattle have been sold.

Present numbers are :—

	Cows.	Bulls.	Young stock.
	89	3	137
as against	74	5	118
at the same date last year.			

During the last two years an attempt has been made to train the young cows to give milk without the presence of their calves. The result has been very disappointing and the practice has had to be abandoned.

The average milk production of the herd has improved considerably owing to a more rigid selection of the cows. This year's additions have been all tested previous to purchase with regard to their milking qualities.

Tuberculin Test.—The milk cows were for the first time subjected to the Tuberculin Test by the local Veterinary Department. None reacted.

Sheep.—The lambing period has been regularized and limited with satisfactory results. Crossing with Dhumba and half-bred Gorakhpore Dhumba rams has been continued. Two Merino rams have been imported for the improvement of the quality of the wool. Some time must elapse before results of any value can be obtained. The first cross between the Gorakhpore and Dhumba breeds, however, results in an improved mutton sheep. Gorakhpore ewes are still used as the female parents in these experiments.

Poultry.—The three breeds, White Wyandotte, Buff Orpington and Chittagong, having proved the hardest and best generally of the large number of varieties tried at Pusa, it has been decided to maintain these and the Mammoth Bronze Turkeys on certain of the Provincial farms and they are being distributed accordingly; new blood will be supplied from England when necessary. The only breed maintained at Pusa in the immediate future will be the Buff Orpingtons.

IV.—PASTURES.

Pastures.—A great improvement has been made in the grazing of both the low-lying and higher pasture areas through topping the grasses before seeding time with hay mowers and occasionally harrowing down the cattle droppings. The effect of rolling, except on newly laid out pastures, is slight.

The economics of laying land down to pasture are being studied. A collection of the more valuable indigenous pasture grasses has been made. These are at present being grown as pure cultures.

V.—CLEARING AND LEVELLING.

Clearing and Levelling.—Thirty acres of land in the low-lying brick-field area have been reclaimed. A considerable amount of levelling has been done in the more suitable fields with a view to increasing the experimental area which is at present very inadequate.

VI.—PROGRAMME OF WORK FOR 1913-14.

Permanent Experiments.—These experiments will be continued. In the low-lying area gram will be substituted for *arhar* in the leguminous rotation on account of the liability of the latter crop to suffer from waterlogging in the rains. In the higher area gram will be alternated with *arhar*. To the green manuring series a plot will be added in which superphosphate is applied to the green manure.

A special study of the maintenance of soil fertility under a double and single cropping rotation will be made.

Field experiments on green manuring in collaboration with the Imperial Agricultural Bacteriologist will be continued.

New Crops.—A special area is being prepared for the trial of new crops.

Cultivation.—Special attention will be paid to the improvement of methods of cultivation of the sugarcane crop, including subsoiling and the improvement of local drainage.

New methods of dealing with heavy soils will be tried.

The improvement of the methods of renewing pastures is under trial and will be continued.

Breeding.—(a) *Cattle.*—The improvement in the milk yield of the Montgomery herd by selective breeding will be continued.

(b) *Sheep.*—The breeding experiments are being continued. The value of the Merino rams as sires for crossing is being tested.

General.—It is expected that the remaining uncultivated arable area will be reclaimed this year.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(J. WALTER LEATHER, V.D., PH.D., F.I.C.)

I.—ADMINISTRATION AND TOURS.

Charge.—This section was in the charge of myself during the whole year.

Establishment.—Mr. H. E. Annett, Supernumerary Agricultural Chemist, continued to officiate as Agricultural Chemist, Punjab, until November when he proceeded on one year and nineteen days' privilege leave and study leave, and has therefore been absent during the whole year.

Mr. Bhailal Motibhai Amin, third assistant, continued on deputation at the Sirseah Indigo Research Station until April 30th, when this station was closed and he rejoined his appointment in this section.

Mr. A. V. Iyer, fourth assistant, was appointed Assistant Agricultural Chemist, Bihar and Orissa, on 3rd November 1912. Mr. Lele was appointed in his place.

Babu Narendra Nath Mitra, M.Sc., an assistant, was appointed demonstrator in Chemistry at the Thomason Engineering College, Roorkee, on 2nd January 1913.

Babu Nirmal Chandra Bose, M.Sc., who was appointed in a temporary vacancy for three months, was appointed an assistant in the Bacteriological Section.

The vacancies which occurred during the year have been filled up by the appointments of Babus Phani Bhusan Sanyal, M.Sc., and Har Dyal Singh, B.Sc., as junior assistants.

It is naturally eminently satisfactory to find that there is such a constant demand for the services of assistants from this section, and this fact at the same time markedly assists recruitment, but on the other hand it means that of the establishment of eight assistants several are always merely under training and of no use for the general work

of the section, much less for research work. I desire to place on record my appreciation of the good services rendered by all, both the gazetted and non-gazetted officers, each of whom has evinced an exemplary interest in his special duty.

Tours.—The following tours were made by myself :—

1. July 1912. To Assam to advise the Scientific Officer of the Indian Tea Association regarding the fitting of the new laboratories.
2. August and November 1912. To Cawnpore and Orai in order to test a new method of determining soil moisture.
3. November 1912. To Marhowrah Sugar Factory to test a filter press.
4. February and March 1913. To conduct tests of sugarcane at the Parsa Factory.
5. March 1913. To the Muttra District to inspect the land included in the Nuh Jheel Project.
6. April 1913. To Cawnpore to test the effect of explosives on Usar land.
7. April to May 1913. To Peshawar to test sugar-beets.

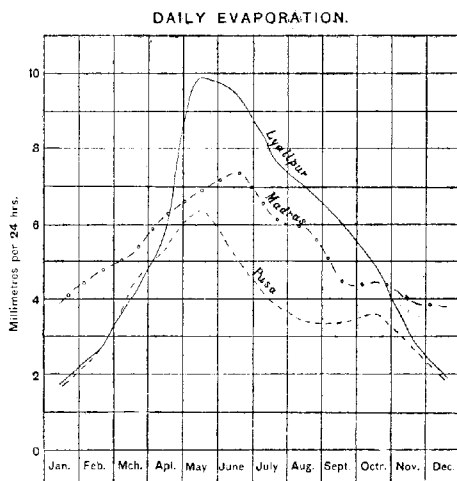
II.—EDUCATION.

Training.—Five students have been under instruction during the year. Of these one Government stipendiary and one private student resigned; one Government student was recalled for duty at the Agricultural College, Sabour, at the end of his first year's course, and the remaining two students are continuing their courses.

III.—METEOROLOGY.

In addition to the usual data which are recorded daily on behalf of the Meteorological Department, records of (a) evaporation, (b) soil temperature, (c) drainage, and (d) pressure by means of a barograph have been maintained.

The records of *evaporation from a plain water surface*, after being maintained for about three years, were concluded during the past year because it seemed that no useful object would be served by more extended records. The data, together with others on the same subject, have been published as a Memoir. With the aid of these data, and others obtained at Lyallpur by the Irrigation Department, an empirical formula was deduced for the calculation of the evaporation at any place in India with the aid of the usual meteorological data. The accompanying chart illustrates



the quantity of water which becomes dissipated per day during the year at Pusa, Lyallpur and Madras. It rises to a much higher figure at Lyallpur during the hot weather than at Pusa or Madras, whilst during the cold weather the rate at Madras is higher than either of the other stations. The total water evaporated per annum is as follows :—

		cm.	ft.
Lyallpur	. . . . .	196	6.4
Pusa	. . . . .	126	4.1
Madras	. . . . .	193	6.3

These quantities are naturally much greater than what is lost from agricultural land. At Pusa the records show that from fallow soil the annual loss is (approximately) 28", at Cawnpore 18". Where crops are growing the quantities of water which are evaporated and transpired are somewhat greater¹ though the difference is not large.

The data regarding *soil temperatures* now extend over two years and they will be written up with a view to publication. They have shown that at Pusa, with a maximum hot weather temperature of, say, 110° F. (43° C.) the following maxima are realised in fallow soil :—

	°F.	°C.
1" from surface	109	43.0
2" from surface	106	41.0
3" from surface	102	39.0
6" from surface	97	36.0

The air temperature of many parts of India rises considerably above that of Bihar. In the Punjab maximum temperatures of 115° to 120° F. (46°—49° C.) are regularly registered for some weeks during the hot season and there the upper soil will naturally attain a correspondingly higher temperature than has been recorded at Pusa.

It has recently been shown² by Russell and Hutchinson that heating a soil to 122° F. (50° C.) occasions material biological changes of a beneficial nature, and that if a soil is heated for a sufficiently long time to 40° C. (104° F.) similar changes may occur.

Such soil temperature records therefore become of some practical importance. At the same time it must not be forgotten that not only is this subject a new one and at present very imperfectly understood, but also that in any case it is only the topmost 3"—4" which are liable to such temperatures, whilst below this depth these biological changes are presumably either modified or non-existent. Also that the cultivating implements annually cause an

¹ *Memoirs, Department of Agriculture in India, Chemical Series, Volume II, No. 2, pages 12—14.*

² *Journal of Agricultural Science, V, pages 152—220.*

intermingling of these various layers or strata; so that conclusions regarding the biological effects of India's hot weather on the soil must be made very guardedly and not in the offhand manner that has been in some instances the case. It may be assumed as certain that "hot weather weathering," whilst valuable in some cases, will be undesirable in others.

IV.—SOIL PROBLEMS.

The records of *drainage* which are obtained by means of the special gauges fully described in the Memoirs¹ have been continued. The nature of the crops grown was changed two years ago. On one gauge sann hemp, *Crotalaria juncea*, is grown during the monsoon and removed in September as near the end of the rains as may be without, however, leaving the land deficient in moisture, after which wheat is sown; on another gauge sann hemp is grown during the monsoon and allowed to ripen thoroughly when it is removed, and this soil then lies fallow. It is too early to draw any conclusions, but so far the wheat crop has not suffered from want of moisture, whilst the sann hemp on the second of these two gauges which is not alternated with another crop, already shows some signs of the deterioration which is so common where a leguminous crop is grown continuously on the same land. The object of the present system of cropping is to ascertain whether the marked deficiency of nitrate in the drainage water, which was noticed when the crops were wheat and maize, would be again experienced. (*Vide* Memoir, Volume II, No. 2, pages 31 *et seq.*)

Soil Moisture.—The investigations regarding the amounts of water present in Indian soils and the requirements of crops which have been carried out for some years by this section, showed the great necessity that exists for a rapid method of determining the amount of water in soils. The usual one of drying a weighed portion of soil in an oven is comparatively very time-absorbing, and

¹ *Memoirs, Department of Agriculture in India, Chemical Series, Volume I, No. 5, and Volume II, No. 2.*

consequently some attention has been paid to this question during the past three years. Hitherto, however, the object has not been successfully attained. Two new methods were tried during the past year, but neither was sufficiently accurate.

Water Requirements of Crops.—During the last monsoon season a series of pot-cultures were made in order to test the effect of different proportions of water in various soils on certain crops, namely, maize and cotton. It is of course well recognised that a too low proportion of moisture in a soil will prevent a full development of a plant, but the information available as to what is a too low proportion or a too high one for any particular soil and crop is extremely scanty, and practically non-existent for India. Moreover, as was to be expected, the effect of a low proportion in a particular soil varied with the crop. Whilst some interesting information was obtained by the pot-cultures, it seemed very doubtful whether this method is suitable for the proper solution of the enquiry; the work will probably have to be undertaken in the field.

Usar Soil.—In January I was requested by the Chief Engineer, Irrigation Branch, Public Works Department, United Provinces, to examine some land in the Muttra District which it has been proposed to bring under irrigation, and to report as to the probability of it becoming saline.

The tract is a section of *khadir* land on the Jumna, and the proposal includes the regulated admission of river water annually for irrigation purposes and its subsequent removal by drainage. Although the wells in the neighbourhood are frequently saline, the soil of this tract is generally very free from any contamination. Tests made on specimens which appeared likely to contain usar salts, showed that these consist of sulphate and chloride only, whilst the more harmful carbonate is absent. Moreover, the soil is very open and easily drained. There was no indication that if the project were carried through harmful results would follow.

The Use of Explosives in Agriculture.—For some short time past the use of dynamite or other similar explosive for the breaking up of "hard pan" or the removal of tree stumps, has been recommended in the press. It is a subject which naturally lends itself to "copy," but should be approached with some little consideration. Experiments have been made at Cawnpore and at Pusa by myself in collaboration with the Chief Chemical Examiner, Ordnance Department, and the Deputy Director of Agriculture, Central Circle, United Provinces, and a separate report will be made. In any case these experiments will have to be considered preliminary, but it may here be suitably remarked that these explosives are comparatively expensive in India at present; also that, whilst it is possible to ascertain immediately to a limited extent what the nature of the effect of the explosive has been in any particular case, its agricultural value can only be subsequently ascertained by the growth of trees or crops on the land. Hence in any case it will only be possible to appraise correctly the financial aspect after the lapse of several years.

V.—SALTPETRE.

After the failure which was referred to in last year's report, a test was made on a small scale with a filter-press. This press, which was borrowed locally, was not only small, but was imperfect in several of its parts. It was, however, sufficiently well repaired to test the probability of such a press being useful, and having shown considerable promise, a large sized one was ordered from Europe. This is expected to arrive shortly, and further experiments will then be made. In the meantime the salt "systems" which are involved, are being worked out by Babu Jatindra Nath Mukerjee, the assistant who is in charge of this work.

VI.—SUGAR.

Date Palm Sugar.—Owing to Mr. Annett's absence no further work on this subject has been done, but the infor-

mation which he collected during the two preceding seasons was published during the current year as a Memoir.¹

Cane Sugar.—As mentioned in my last report, tests had been made over two seasons of the experimental error which is involved when a "sample" of cane is taken from a field or plot of this crop. Dr. Walker, the Director General of Observatories, very kindly examined the results which I had obtained, and acting on suggestions which he made to me, a third series of tests were carried out during the past season. These resulted in more definite information and showed clearly what the probable error is when the sample is taken by certain methods. The matter has been put together for publication as a Memoir and is now in the press.

Sugar Beet.—Reference was made in my last annual report to the fact that some very good specimens of sugar beet had been grown at Peshawar by Mr. Robertson Brown, the Superintendent of Farms. This year I took apparatus to Peshawar and tested the fresh roots, which is naturally more satisfactory than testing them at Pusa after a long railway journey. A considerable number of individual roots were tested, as also average samples of 100 roots each from each field. A good deal of variation in size and quality was met with among individual roots, the percentage of sucrose varying from 9.0 to 20.0. The average samples tested 15.8 per cent. and 15.3 per cent. sucrose respectively, thus showing conclusively that this crop can be successfully cultivated in that part of India. The above percentage of sugar is materially better than some of the initial crops which were raised in San Francisco when the industry was first started there. I understand that the experiments will be extended considerably during the present year. There can be no doubt that this crop possesses great potentialities.

VII.—MILK.

Reference was made in last year's report to a series of tests, which was being made in conjunction with my col-

¹ *Memoirs, Department of Agriculture in India, Chemical Series, Volume II, No. 6.*

league Mr. Dobbs, of the quantity and composition of the milk of the Montgomery herd that is maintained here. The work was continued in the autumn and it is proposed to publish the records shortly.

VIII.—PROGRAMME OF WORK FOR 1913-14.

Major subjects :—

1. Investigations of the availability of plant food in soils will be continued.
2. Experiments on possible improvements in the refining of saltpetre will be continued.
3. The variations of certain physical and chemical properties of individual seeds of the same plant are being examined.
4. The records of the amount and nature of drainage water from fallow land and from land under crops are maintained.

Minor subjects :—

5. An attempt is being made to ascertain the nature of the hydration of clay in soil.
6. The permeability of soils to water is being studied.
7. The relation of moisture in cereal grains to weevil attacks and the manner of absorption of certain insecticides is being examined in collaboration with the Imperial Entomologist.

Education.—This requires no special comment and will be conducted according to the lines laid down.

IX.—PUBLICATIONS.

The following have been published :—

1. The Date Sugar Industry in Bengal. H. E. Annett. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. II, No. 6.
2. Evaporation from a Plain Water Surface. J. Walter Leather. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. III, No. 1.

3. The Experimental Error in Sampling Sugarcane. J. Walter Leather. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. III, No. 4 (*in the press*).

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(A. HOWARD, M.A., A.R.C.S., F.L.S.)

I.—TEACHING, TRAINING AND STAFF.

Charge.—I held charge of the section at Pusa during the year under review till April 28th, when I took six months' combined leave. The Second Assistant, Maulvi Abdur Rahman Khan, was placed in charge of the current work of the section at Pusa, and the Third Assistant, Munshi Ijaz Husain, was placed in charge at Quetta during my absence.

Students.—One advanced student from the Madras Agricultural College worked in the section from October 1st, 1912, to the end of April 1913. He has, I understand, since obtained an appointment at Coimbatore in the Provincial Agricultural Department.

Staff.—The work of the staff continues to be satisfactory. The Second Assistant has done excellent work at Pusa while the Third Assistant at Quetta has done well. The two fieldmen, Sarup Singh and Ram Pershad, and the clerk, Babu Ram Nechhawar Lal, worked well during the year.

II.—WHEAT INVESTIGATIONS.

The wheat investigations continue to extend and during the past year results of considerable value have been obtained.

Distribution of Pusa Wheats in India.

The growth of Pusa wheats in the various wheat-growing tracts of India has now emerged from the experimental stage and the distribution of seed is in progress on a large scale in Bihar, the United Provinces, Central Provinces and, to a limited extent, in the *barani* tracts of the Punjab.

Extensive seed farms for the growth of these wheats are now in working order and high grade seed, true to type, is being supplied in large quantities to the public.

The preliminary work relating to the improvement of the Indian wheat crop need only be referred to very briefly. One of the first practical results of the wheat investigations at Pusa was the demonstration of the fact that varieties with milling and baking qualities, similar to those of the best wheats on the English market, could be grown in Bihar under *barani* conditions. By the application of modern methods of selection and hybridization these high grain qualities were successfully combined with high yielding power, rust-resistance and strong straw so that wheats were found which gave, on land in fair cultivation, upwards of 2,500 lbs. of grain to the acre without irrigation. The milling and baking tests connected with this work were carried out in England by Mr. A. E. Humphries, a past President of the Incorporated Society of British and Irish Millers and a well-known authority on these questions. Mr. Humphries reported that the Pusa wheats were a great advance on those exported from India and behaved in the mill and bakehouse like Manitoba spring wheats, which are in greatest demand for bread making in England and which command the highest prices on the Home markets. At the same time enquiries were made in India itself as to the suitability of the new wheats as food for the people. In all cases both cultivators, landholders and the educated community preferred for their own food the Pusa wheats to those ordinarily grown in India.

The next step was to determine whether or not grain quality would be affected by growing these wheats in different localities in India and particularly under canal irrigation. In collaboration with Mr. Leake and with the assistance of a large number of officers of the Agricultural Department this work has been undertaken and the same wheat has been grown for several years at a large number of stations in the various wheat tracts and the samples have been tested by Mr. Humphries in England. The fact

has been demonstrated that wheats of first-rate quality can be grown under canal irrigation on the alluvium and also on the black cotton soils of Peninsular India.

During the past year the earlier results have received important confirmation. Pusa wheat grown in the Indus valley and on the black cotton soils has given better results in the mill and bakehouse than the same variety grown at Pusa. The general results are summed up in Mr. Humphries' last report as follows :—

“ It has again been demonstrated that wheats of the highest class can be grown in India on several kinds of soil, and on land which has been irrigated. It has been shown that the high excellence of quality possessed by wheats grown at Pusa in previous seasons was not due to environment or agricultural practice, for the same varieties of wheat have yielded still better results elsewhere. It is interesting to note that this high excellence of quality was found existing in wheats indigenous to India, and that in the Pusa Nursery varieties, the progeny appear to possess intact the great strength of the strong parents. I have no doubt that any or all of the wheats tested will realize, some at once, some later, relatively higher prices on our markets than the existing Indian wheats of commerce. If these new varieties yield no more grain and straw per acre than those ordinarily grown, their extended distribution as seed is desirable; if, in addition, the new varieties will yield greater quantities of grain and straw than those ordinarily grown, the position of the Indian grower will be greatly improved, and the propagation of the new kinds should be pressed forward.”

The most important feature of this last series of tests was the superiority, in the mill and bakehouse, of the samples of Pusa 12 from three stations in the Indus valley (Lyallpur, Mirpurkhas and Gurdaspur) over those grown in the Ganges valley. The significance of these results lies in the fact that high grain quality can be obtained in all the great wheat-growing tracts of India including the Punjab

and the black cotton soils of Peninsular India, both under dry and irrigated conditions. This is an important matter and one which must be considered in all schemes of wheat improvement. There is no longer any reason why (now that it has been shown that yield and quality can be combined in the same wheat) the distribution of poor quality wheats should be continued.

The attention of the wheat trade at Home has been drawn to the work in progress on the improvement of Indian wheat. A meeting was arranged this summer by Mr. Humphries at Weybridge with Mr. Petrie, the London Manager of Messrs. Ralli Brothers, when samples of Pusa 12, grown at the various stations in the Indo-Gangetic plain and on the black cotton soils of Peninsular India, were exhibited. The loaves obtained from this wheat were also shown side by side with those produced from the grade known as Choice White Karachi and No. 2 Northern (Manitoba). The loaves from Pusa 12 were almost identical with those from No. 2 Northern and were a great improvement on those obtained from Choice White Karachi flour. The opportunity was taken of obtaining Mr. Petrie's advice as to the best means of disposing of these wheats on the Home markets and of establishing the reputation of a grade of Indian wheat with superior quality. In addition, a sample of Pusa 4, grown on the Hathowrie Estate in Bihar in 1912-13, was exhibited at Mark Lane at a recent meeting of the Council of the Incorporated Association of British and Irish Millers where the wheat attracted a considerable amount of attention.

The present position of the cultivation of the Pusa wheats in the various wheat-growing tracts of India must now be considered. The work is being carried out by many officers of the Agricultural Department and the details given below have been obtained, partly from the publications and reports issued in the various provinces and partly by correspondence.

United Provinces.—The first experiments with Pusa wheats in these Provinces were made in the Botanical area

at Cawnpore by Mr. Leake, who showed for several years that fine samples could be grown under canal irrigation using far less water for the purpose than is ordinarily given to wheat. During the progress of this work at Cawnpore, the Allahabad Exhibition took place and at the Agricultural Conference which was held in connection with the Exhibition the Pusa wheats were shown. As a result, the Manager of the Court of Wards' Estates in the District of Kheri, Mr. Hoskins, became interested in the matter and some of the new wheats were grown successfully by his tenants in the season 1911-12. The results obtained from these various experiments led to a demand for seed. As the land available for wheat in the Botanical area at Cawnpore was not sufficient for seed-growing purposes, it was decided by Mr. Leake to utilize about 100 acres of the new farm at Kalai, near Aligarh, for the purpose of growing seed for distribution. The first crop was grown in the season 1912-13 and the yields of the various wheats over large areas are given below. Mr. Leake states that there was a failure of the canal and consequently some damage by white-ants, and that these facts must be considered in judging the outturns.

Yield of Pusa wheats at Kalai near Aligarh, 1912-13.

Name.	Yield in lbs. per acre.
Pusa 12	2,214
Pusa IX A 2	2,050
Pusa 101	2,010
Pusa 4	1,928
Pusa 110	1,846
Pusa IX E 9	1,702
Pusa 8	1,640

Trials were also carried out at the farms at Partabgarh and Benares where the following returns were obtained by Mr. Sharma, the Assistant Director of Agriculture :-

Yield of Pusa wheats at Partabgarh and Benares, 1912-13.

Name.	Yield in lbs. per acre.
Pusa 12	2,020
Pusa 8	1,960
Pusa 106	1,928
	} Partabgarh.
Pusa 12	2,040
Pusa 106	1,856
Pusa 8	1,760
	} Benares.

The results obtained on the various Court of Wards' Estates were also successful, particularly on the Kheri estates. The season was not favourable to wheat, due to a prolonged drought and scarcity of irrigation water, followed by high winds and storms in February and March. Both Pusa 8 and Pusa 12 did well with the small amount of water the wells could supply, and being strong-strawed wheats stood up while the surrounding crops were laid by the storms.

The distribution of seed in this Province is being taken up energetically by the Agricultural Department. In the Central Circle, Mr. Burt, the Deputy Director, has issued seed for about 1,800 acres, largely to Co-operative Societies and Court of Wards' Estates. A large demand for seed has also arisen in the Eastern Circle as well as in the sub-montane tracts and a good deal of seed has been distributed in these areas. More, however, could have been distributed had seed been available, but in spite of a considerable amount being supplied by the seed farm at Dholi, near Pusa, the supply was not equal to the demand and the later indents could not be met. A large amount of seed, sufficient for all demands, should, however, be available in the Province next harvest.

Punjab.—During the past *rabi* season an extended trial of one of the Pusa wheats (No. 12) has been carried out by Mr. Southern, the Deputy Director of Agriculture, at the

Gurdaspur Experiment Station. The object of the trial was to compare the behaviour of this white wheat with high grain quality, with Punjab Type 13, a low grade red wheat which was found to be the best yielder of the local kinds. The trials were in duplicate on plots from two to three acres in area and the yields obtained are given in the following table :—

Trial of Pusa 12 and Punjab 13 at Gurdaspur, 1912-13.

Name.					Yield in lbs. per acre
Pusa 12	.	.	.	.	1,570
Punjab 13	.	.	.	.	1,161
Pusa 12	.	.	.	.	1,096
Punjab 13	.	.	.	.	1,081

The season was an unfavourable one for wheat. The monsoon ceased in August and no more rain fell before sowing time. After a single day's rain in November, there was a long drought, the Christmas rain failed and the crops were drying up when the storms of February and March improved matters. Hot winds in April, however, ripened off the crop too rapidly and the local variety was poor and shrivelled. Pusa 12, however, gave a very good uniform sample in spite of the unfavourable conditions and a good yield. This is the second time Pusa 12 has done well at Gurdaspur. Seed of this wheat is now being sold to zemindars in the *barani* tracts and it will be interesting to know their experience with this variety.

Pusa 12 has also been grown under canal irrigation by the tenants of the Lyallpur farm who obtained 1,744 lbs. of grain to the acre. The grain is of superior quality and it is probable that this wheat will do well when tried by the cultivators of the Chenab Colony.

Bihar.—The main lines of progress in Bihar during the past year relate to the organisation of seed farms and the supply to the public of well-grown seed, true to type, at a reasonable price.

In connection with the Bihar Planters' Association an arrangement has been made with Mr. Edward Danby to grow a large area of Pusa wheats on the Dholi and Bowarah estates near Pusa so that a large amount of good seed will be available. This arrangement has been carried out successfully and about 600 acres of wheat were grown in the *rabi* season of 1912-13. Care was taken to rogue the plots, to keep the various kinds separate and to sell for seed only dressed grain of a high grade. The price charged was one rupee per maund above local bazaar rates and the whole seed supply was sold off at once immediately after harvest. Orders for upwards of 1,000 maunds could not be filled. These arrangements are being continued and during the present wheat season about 700 acres have been put down for seed wheat on these estates. The advantages of this method of seed supply are obvious. The expansion of the work is ensured at practically no cost to Government and the estates where the crop is grown to perfection for seed serve as useful demonstration areas to all interested in wheat growing. Further, the profits obtained by the estates should attract the attention of cultivators and zemindars to the advantages, to all concerned, which follow from a supply of good seed.

The returns obtained on this seed farm over large areas are given in the table below. The season was not favourable to wheat. Damage was done by abnormal heat after sowing time and also by a series of storms in February and March which laid the neighbouring crops. Most of the Pusa wheats, however, having good straw, stood well and in spite of the season gave good yields. Great advantage was obtained on this and other estates in Bihar by harrowing the young crops by means of lever harrows.

Yield of Pusa wheats at Dholi and Bowarrah, 1912-13.

Name.	Average yield in lbs. per acre.
Pusa 100	2,050
Pusa 4	1,846
Pusa 8	1,886
Pusa 12	1,640
Pusa 6	1,635

In addition to the seed farms near Pusa under the immediate control of the Imperial Economic Botanist, the distribution of these wheats has been taken up by the Bihar Agricultural Department and seed has been grown at Sabour, Dumraon and Bankipore. Seed for about 200 acres has been distributed by Mr. McGowan in the Bhagalpur Division while the successful trials of these wheats in the Patna Division will be continued. The yields obtained on the light lands of the Sabour farm are given below.

Yield of Pusa wheats at Sabour, 1912-13.

Name.	Yield in lbs. per acre.
Pusa 7	1,809
Pusa 12	1,664
Pusa 8	1,512
Pusa 106	1,087

Many of the indigo estates in Bihar are now taking up wheat growing and there is a considerable amount of local seed distribution in progress. It is impossible to obtain returns of these operations and to say what is the total area under wheat.

During the year two new Pusa wheats have been tried on estates in Bihar, namely, Nos. 4 and 6. The former is an early maturing wheat with strong straw which is very suitable for sowing with Java indigo. This wheat did well in 1912-13 and returns from 1,558 to 1,912 lbs. of seed to the acre were obtained on the various estates where it was grown. At Belsund factory Pusa 6 gave 1,640 lbs. of seed

to the acre which Mr. Reid considered very good for the year.

Central Provinces.—The results obtained in the Central Provinces at the Raipur and Tharsa farms by Mr. Clouston during the past year amply confirm the earlier successful trials of these wheats on the black soils which are referred to in detail in the annual report for 1911-12. A somewhat extraordinary result was obtained at Tharsa with Pusa No. 7 where the yield was 1,240 lbs. to the acre. As the outturn of the local kinds seldom exceeds 600 lbs. to the acre a yield of 1,240 lbs. to the acre is quite exceptional. The actual results of the growth of these wheats by the cultivators in the Eastern Circle have not yet been received as Mr. Clouston is on leave, but it is understood that they have been successful.

So far only one wheat, Pusa 4, has been tried at Hoshangabad. The results were satisfactory. This kind is also being tried at Jubbulpore by Mr. Evans who has this year asked for a further supply of seed.

The results of the recent milling and baking tests of Pusa wheats grown at Raipur, Tharsa and Hoshangabad are of considerable importance. The behaviour of these samples was somewhat better than that of the same wheats grown at Pusa and other stations in the Gangetic plain. As high grain quality is now shown to be possible on the black cotton soils of the Peninsula, a great improvement in the wheats grown can easily be accomplished.

Wheat Breeding.

Practically all the first set of improved wheats obtained at Pusa by selection and hybridization have been tried on the large scale in various tracts in India and the most suitable of these are now being grown for distribution on various seed farms. These wheats will be grown on, at Pusa, in pure culture, so that when necessary the seed farms can be re-stocked with a fresh supply of seed of any particular variety.

During the testing of these early selections and hybrids, considerable progress has been made in the work relating to a new set of crosses which promise to give still better results than the earlier ones. The object in view in this work has been to improve the best of the Pusa wheats in standing power, rust resistance and also in general hardiness. For this purpose crosses between Indian wheats, with good grain quality, and various English and American varieties were made in England in 1910 and two series of these hybrids are now in the fourth generation. This is by far the most promising material yet obtained at Pusa and it is more than probable that the strong straw, rust resistance and general vigour and hardiness of the English parent has been, as it were, introduced into Indian wheats. The fixation, isolation and testing of new wheats from these series is not likely to be a long process. Experience continues to confirm the paramount importance of standing power in any further progress in the improvement of the Indian wheat crop.

III.—OTHER INVESTIGATIONS.

Tobacco.—Substantial progress has been made during the year in the tobacco investigations at Pusa.

The only type of Indian tobacco found suitable for cigarettes in Bihar, when cured by the country method, is one known as Type 28. This was grown on a fairly large scale on the Dholi Estate during the last tobacco season and the crop was cured on the ground—an assistant being lent from Pusa to show the factory staff how to proceed. The yield of cured leaf to the acre was very satisfactory and the product was taken over by the Indian Leaf Tobacco Development Company at Dalsing Serai. This year a larger area is being grown on the Dholi Estate. The spread of the cultivation of this kind is now a matter of price. If the growers are able to obtain a premium for this kind from the Company to repay them for the extra care required in the curing process the area will expand. On the other hand, it must be remembered that there is no competition

on the part of the local trade for this tobacco when grown for cigarettes and at present the Company can to all intents and purposes make its own terms. This year a good deal of seed of this kind has been distributed not only to planters in Bihar, but also to Government farms in the Central Provinces and in the United Provinces.

Experience in tobacco growing in Bihar discloses the fact that every year the growers suffer a large amount of loss of crop and waste a good deal of labour. Both can be avoided. These losses are due to the primitive methods of growing the seedlings, to the frequent loss of the majority of the first sowings and to numerous casualties after transplanting, resulting in a very uneven crop. Experiments were made during the past year with a view to remedy this state of affairs. The seed beds were partially sterilized by making fires on the surface before sowing and also by heating the upper soil in pans. The results were exceedingly promising—the seedlings on the partially sterilized beds were much stronger than the rest and were ready for transplanting about a week before the others. These experiments are being extended and other methods of partial sterilization such as steaming are being tried.

A paper dealing with the results obtained on the inheritance of characters in this crop has been written by the Personal Assistant. This work is of interest from several aspects. It was undertaken with a view of obtaining some general idea of the best method of attacking the problem of the improvement of the quality of the Bihar tobaccos—more particularly from the cigarette tobacco standpoint. From the practical point of view the possibilities of obtaining better tobaccos by breeding have been shown to be certain, and several promising sorts have been isolated during the progress of the work. From the scientific aspect it has been shown that, provided proper precautions are taken, the inheritance of quantitative characters, such as those relating to the size and shape of a tobacco leaf, follows the Mendelian scheme. In this paper the results obtained on the inheritance of the factors concerned in the size and shape

of the leaf are new, and mark an advance in the application of modern methods of plant breeding to crops of economic importance.

Gram.—The selection experiments with gram referred to in the last annual report have been continued. The season was not very favourable to gram as the seed bed was too wet due to the storms of November followed by heavy rains at flowering time. The high yielding white gram, which in 1912 was valued at Rs. 5-8 per cwt. f. o. r. Bombay, again did well at Pusa and seed of this and of some of the other kinds is being tried in Bihar and also on various Government farms in the Central Provinces and in the United Provinces.

Fibres.—A good deal of work was done during the year on fibre plants, particularly with regard to the inheritance of characters in *Hibiscus Sabdariffa*. This is being continued and it is expected to publish the results obtained during the coming year.

In the case of *Hibiscus cannabinus* the promising kind, known as Type 3, has been grown for fibre with satisfactory results. Seed of this kind will be offered to the various Provincial Departments of Agriculture during the present year.

Methods of pollination.—Observations on the methods of pollination in the various crops grown at Pusa have been continued and an effort will be made next year to publish the results.

Indigo.—In consequence of the decision to close the Sirsiah Experiment Station, the work on indigo formerly carried out there was transferred to the Botanical Section at Pusa at the end of the last financial year. Six small tubes of selected indigo seed were received from Sirsiah and these have been sown at Pusa. In addition, a large number of indigo experiments were started at Pusa in October 1912 in continuation of those begun the year before. The indigo industry, which is now in a declining condition, presents three problems for immediate solution. In the first place, the best methods of growing Java indigo so as to avoid the

loss of plant during the late monsoon due to "wilt" have to be worked out at an experiment station and then tried on the large scale on estates. Secondly, the best way of growing good seed of this crop in Bihar has to be discovered. At present, the seed supply is erratic and often far below the demand. Lastly, the methods of pollination have to be investigated with a view to deciding whether or not there is any scientific basis for the idea that this crop will repay the application of modern methods of selection and breeding. Considerable progress has been made in this work, particularly on the successful treatment of "wilt" and some results of undoubted value have been obtained. If possible, a separate report will be submitted early in 1914 dealing with the position of the investigations to date.

In connection with the work on indigo some reference should be made to the relations which have arisen between the Botanical Section and the Bihar Planters' Association. Since the Tirhut Exhibition was held at Pusa in January 1912, two addresses have been given to the Planters' Association at Mozafferpore dealing with the various improvements in local agricultural practice discovered in the Botanical area at Pusa in the course of the plant breeding work. These addresses, which were given at the request of the President, were well received and were, during the present year, published in the form of a bulletin entitled *Some Aspects of the Agricultural Development of Bihar*. Particular attention has been drawn to the value of hot weather cultivation in Bihar, to the annual losses due to want of drainage combined with erosion by rain wash, to the value of green manuring with *sunn* on the higher well-drained lands and to the use of labour-saving devices in the shape of small cultivators, lever harrows and improved ploughs.

IV.—WORK DONE IN EUROPE.

While on leave in Europe during the present year a certain amount of work was accomplished relating to the investigations in progress at Pusa and Quetta.

Agricultural Exhibitions.—Two large Agricultural exhibitions were visited, namely, the Royal Agricultural Show at Bristol and the Agricultural Exhibition at Munich in connection with the 'Oktoberfest.'

At Bristol some attention was paid, at the request of the Government of India, to the Overseas section—a new departure at the Royal Show in which the assistance of India was requested. Government decided not to participate at present but to ask two of the officers of the Agricultural Department to submit a joint report on the nature and objects of this section of the Exhibition. Exhibits were sent not only by the Self-governing Dominions (Australia, Canada and South Africa), but also by some of the Local Governments of the Dominions (Victoria, South Australia, Queensland and Western Australia) and by various Crown Colonies (Federated Malay States, British West Indies and British Guiana) and Rhodesia. In addition, various Companies dealing with emigration sent large exhibits, such as the Orient Line, the Dominion Settlement Association, the Canadian Government Emigration Department, the Canadian Northern Railway and the Canadian Pacific Railway. India was represented by a small stall sent by the Department of Agriculture, Bengal. The feature of the Overseas section as a whole was the inducement held out to emigrants—labourers, small holders and farmers—to settle in the new countries. The exhibit of products was evidently a subsidiary matter and it was clear that the advantage to India of participating in such an Exhibition in the future would be almost negligible in proportion to the trouble and expense involved.

Some time was devoted both at Bristol and at Munich to the modern developments in the manufacture of agricultural implements which is not without interest to India at the present time now that the Co-operative movement is spreading and the purchasing power of the cultivator has been increased by union and is no longer limited by his individual resources. At Bristol particularly and to a less extent at Munich, the feature of the display of implements

was the attention that is now being paid to the design of chief machines of light draught suitable for small holdings. A large number of small firms are engaged in the business and as the tendency in Great Britain is all in favour of small holdings, it seems probable that among the implements designed several will be found of use under Indian conditions. There were also many designs of portable petrol engines of small power for agricultural purposes including several threshers driven in this manner. The contrast between the small handy implements exhibited at Bristol and the collection of heavy agricultural machines at the recent Allahabad Exhibition was most striking.

Fruit packing.—Some attention was paid to the progress in the methods of packing fruit which is going on in connection with the produce sent to the London market. Some new packing materials were observed which are said to be very successful. These will be tried during the next year at Quetta and if found useful under Indian conditions will be brought to the notice of those concerned. It is quite probable that the cost of the present packages used at Quetta can be materially reduced and work in this direction is already in progress.

Experiment Stations.—Visits were paid to the four leading experiment stations in Great Britain—Rothamsted, Merton, Cambridge and Long Ashton. Very important work is in progress at Rothamsted, particularly on the factors influencing the fertility of soils and on the accurate determination of the products of assimilation in leaves. The feature of the plant breeding station at Merton in addition to the great variety and interest of the problems in hand is the high standard of cultivation reached both in the green houses and also in the numerous plots outside. Everything was thriving and well grown and one left with the impression that Great Britain possesses at least one modern experiment station characterised by real vitality. At Cambridge some time was spent with Professor Biffen in going over the plant breeding work on wheat and other crops which is now being greatly extended. An area

of land is being taken up for plant breeding purposes only, where the new varieties can be grown on a moderately large scale before being issued to the farmers. At Long Ashton near Bristol, a visit was paid to the Fruit Experiment Station in connection with the National Fruit and Cider Institute where a good deal of useful and interesting work has been done.

At most of the experiment stations in Great Britain extensions are in progress due to the funds set free by the Development grant. There is a marked tendency to endow agricultural investigations, to make the work continuous and to render it independent of what may be described as irregular and precarious support. The progress of the work under the Development Commission cannot fail to be of interest to all concerned with the task of improving the rural economy of India.

Wheat.—The opportunity was taken of several consultations with Mr. Humphries relating to the work in hand on the improvement of Indian wheats and the testing of the resulting samples. Visits were also paid to Mark Lane and the Baltic and the most reliable advice available in London was obtained as to the best way of introducing the new Indian wheats to the trade and marketing them to the greatest advantage. In all these matters Mr. Humphries was invaluable and he spared no pains to help the work in every way.

Publications.—A memoir on the inheritance of characters in tobacco was passed through the press in England with a view of comparing the work done in Calcutta and London and the corresponding cost. The result was to show that printing and illustration work is both cheaper and better in London while the labour of passing a paper through the press there is materially reduced.

Drainage.—The opportunity was taken of examining the methods of drainage in use in northern and central Italy and the care taken in these tracts in freeing the arable land of excess water. The method adopted is identical in principle to that worked out in the Botanical area

at Pusa, but in some details the Italian practice is an advantage. Steps are being taken to improve the Pusa method. The progress that has taken place in Italian agriculture during the last fifteen years is remarkable not only in general cultivation, but also in the spread of the co-operative movement. In many respects the conditions in Italy are not dissimilar to those in India and might easily repay detailed investigation.

V.—THE DEVELOPMENT OF THE FRUIT INDUSTRY OF BALUCHISTAN.

The present report deals briefly with the work accomplished up to September 1912 relating to the development of the fruit industry of Baluchistan and with the chief lines of progress which experience suggests should be taken up in the near future. It will be convenient to deal with the matter under the following main heads :—

Fruit and Agricultural Experiment Station.

An area of 25 acres of land with two *shabanas* of water of the large Sirkhi *karez* has been acquired by the Local Administration for the purposes of a fruit and agricultural experiment station on the Sariab Road about two miles from Quetta. The purchase was completed at the end of August 1911 (with the exception of one of the *shabanas* which was bought in June 1912) and since that time the farm buildings, offices and boundary wall have been erected, a well sunk, and considerable progress has been made in the laying out of the area in large terraces to facilitate irrigation. Three artesian bores have been sunk which give a total flow of 1,500 gallons per hour. A fourth bore is being put down to the water-bearing gravel at the 150' level. An experiment in pumping from one of these artesian bores by means of an oil engine is in progress and will, it is expected, be completed shortly. At the present time, bricked water channels are being laid down and various other permanent improvements are in progress. Four pairs of Sibi cattle

have been purchased and a supply of implements collected. Progress has been made in the enlistment and training of the staff.

While most of the year has been taken up with preliminary spade work in connection with the laying out and levelling of the land previous to planting in November 1912, nevertheless a few results have been obtained. These are as follows:—

1. *The raising of nursery stock.*—The usual practice in Quetta up to the present, both in the Government gardens and in those of zamindars, in the raising of new trees has been to side-bud on two or three years' old stocks, the time taken in raising budded trees being two or three years. This year it has been found that if the seedling stocks were ring-budded in May and June, strong plants can easily be raised ready for planting within a year of the sowing of the seed of the stock. This is an important matter from the point of view of the revenue of the station and also from the standpoint of a large supply of good trees for replacing the old fruit gardens and for new planting. The supply of good and abundant planting material for the Province will in future years be a simple matter.

2. *The saving of water.*—The most important direction in which the agriculture of Baluchistan can be improved is in the saving of water and in making the greatest possible use of the present supplies. Attention has therefore been paid to this matter and results of importance have been obtained. By means of surface cultivation after the winter rains, it has been found possible to conserve the moisture in the soil to a very considerable extent and this can easily be applied to the growth of wheat and fruit trees. It has already been taken advantage of in the raising of nursery stock and in the growth of tomatoes. The soil of the valley is also suitable for furrow irrigation so that there is every prospect that by means of this method of watering, combined with clean weeding and surface cultivation, the present water supply of the valley can be shown to be able to produce at least twice the crops grown at present.

3. *The use of green manure in Baluchistan.*—Closely bound up with the conservation of moisture by surface cultivation and improved methods of irrigation is the supply of organic matter to the soil so as to increase its water-holding capacity. The geological history of the Province suggests that the soil is likely to be deficient in organic matter. This is confirmed by the local agricultural practice in which large quantities of manure are employed. The easiest method of adding this organic matter would be to grow some leguminous plant on the winter rains and when irrigation water is available and to turn this into the ground in April and May. The best crop for the purpose appears to be clover (*shaftal*) and accordingly some of this was put down in the autumn of 1911. Two or three cuts were obtained, which were sold to the Military Dairy, and the next crop was ploughed in as a green manure. The soil was greatly improved and it is practically certain that this crop will prove of great value in the Province, as it will not only improve the tilth and fertility of the soil, but also increase its water-holding capacity. A good deal of work remains to be done to find out the best methods of utilising this crop to the greatest advantage in the rural economy of the Province.

4. *The arrangement of fruit gardens.*—At the present time there is little or no arrangement in the fruit gardens in the valley and there is no separation of the trees into early, mid-season and late so as to facilitate watering and picking. There is no order or method so that a vast amount of unnecessary work is done in gathering the fruit and a good deal of water is wasted, as it is almost impossible to water a few trees without irrigating the whole garden. To obviate this, a beginning has been made in the collection and propagation of the best local varieties which will be planted out systematically. A sufficient supply of trees has been raised this year and care has been taken to keep accurate nursery records. A few French trees have been imported and it has been arranged to introduce all the best kinds from the South of France next February so that

the experiment station will possess a wide range of kinds, many of which it is hoped will be useful for propagation. This collection will be of the greatest use in the future development of fruit-growing in Baluchistan.

The Renovation of a Neglected Fruit Garden.

At the request of the Hon'ble Colonel Ramsay, C.S.I., C.I.E., Agent to the Governor General in Baluchistan, the southern portion of the Quetta Residency compound—an area of about 14 acres—was taken up as an experiment in renovating and replanting a derelict and neglected fruit garden. The land was taken over in October 1911, but a supply of convict labour was not arranged for till July 1912 so that this portion of the work has been delayed to some extent. Progress, however, has been made and this garden is being cleared, graded and the land brought into cultivation. As much as possible will be sown with *shaftal* this autumn and some of the plots will be ready for planting in trees in November 1913, the trees, which are ready now, being grown on in the nursery till that date. Notwithstanding the bad state of this area when taken over, there is little doubt that it can be made to yield a good return provided the water supply from the Barnes and Tari *karezes* can be ensured and the present thefts of water prevented. The revenue of the year is expected to reach at least Rs. 1,000 which is more than the working expenses. This should increase considerably when the new trees come into bearing and till that time a large revenue should be obtained from *shaftal*.

During the present year two results of importance were obtained in this area:—

1. *Tomato cultivation.*—Except in the private garden of the Agency Surgeon (Colonel Duke), the cultivation of tomatoes does not appear to be understood in Quetta although the crop is easily grown. It was therefore decided to try an experiment on a large scale with tomatoes trained on the two-branch system of Colonel Duke combined with furrow irrigation, as is practised at Pusa in the case of

tobacco. A preliminary trial of this system was carried out at Pusa last cold weather, where it proved a great success. On repeating the experiment at Quetta, the assistant in charge failed to raise a proper supply of seedlings by the time I arrived in May, so that a miscellaneous collection of seedlings left over in the gardens of various vegetable-growers had to be collected and the best made of this very inferior planting material together with a small supply of plants raised by the Overseer of the Residency Garden. The plants, however, did better than was expected and up to the time of writing (September 19th) the income from an area of four-tenths of the acre has exceeded Rs. 600. About half of the fruit is not yet ripe and of this a good deal has already been destroyed by the early frosts. There is no doubt, however, that if the tomato seedlings are raised at Sibi and planted in good time for the whole crop to ripen before the cold weather sets in, the income from an acre of tomatoes (sold at Rs. 3 per maund) would result in a clear profit of Rs. 1,500 per acre at least. The amount of water required is small and the expenses of training and pruning are not very great. The experiment will be continued next year and will be conducted by Hira Lal, the Overseer of the Residency Garden. The experiment has greatly impressed the local growers, and has attracted a good deal of attention. Several vegetable-growers propose to take up this method of growing the crop next year.

2. *The transport of tomatoes.*—In order to test the demand for Quetta tomatoes in the Calcutta market, twelve crates of fruit have been exposed for sale in the shop connected with the Great Eastern Hotel. Packed in crates holding 24 chip baskets, each holding one seer, the fruit reached Calcutta in excellent condition and was sold at twelve annas per basket. This leaves a margin of profit of Rs. 12 per crate of 24 scers.

3. *The yellowing of peach trees in Quetta.*—In the Civil Station of Quetta, the peach trees have, as a rule, very yellow foliage, often accompanied by excessive gumming. Such trees are said to die very quickly and this experience has

been confirmed by the death of many trees this year which showed these symptoms markedly last year. Over-watering and want of cultivation do not appear to be the cause of the yellowing and there are no indications of insect or fungoid disease. The early symptoms appear to be identical with the mysterious disease in the Eastern United States known as "Peach yellows," but the later symptoms of "Yellows," namely, premature ripening and reddening of the fruit with very poor flavour, are not developed. The yellowing is therefore fortunately not due to "Peach yellows." The next point to settle was whether or not the yellowing is caused by unfavourable soil conditions. Evidence was obtained during the summer indicating that the yellowing is due to the soil and that green manuring with *shaftal* may prove to be the best remedy. The yellow condition does not appear to be propagated by buds taken from affected trees, as both these trees and trees with green, healthy foliage gave rise to budded plants which appeared equally healthy. Experiments are in progress to test these ideas still further and definite evidence on the subject should soon be forthcoming.

Packing Experiments.

During 1911, a considerable amount of attention was paid to the improvement of the present methods of packing fruit at Quetta with a view of making the most of the present railway transport to India. The results obtained were dealt with in detail in the progress report of 1911 and can be shortly recapitulated as follows:—

1. Returnable packages for long journeys in India are unsuitable on account of the cost of returning the empty boxes and on account of the frequent mistakes on the part of the Railway Company in charging the wrong rates.
2. All packages must be designed to prevent as far as possible thefts in transit by the railway servants. The frequent occurrence of these thefts is a great obstacle to the extension of the Quetta

fruit trade as the expense and trouble of sealing numerous small packages is very great. It should be possible, if the matter is strongly represented to the Railway Board, to fix the responsibility for the packages on certain individuals and to prevent cases of thefts in a manner which would not make it worth while to continue these malpractices.

3. Except for short distances, cheap non-returnable packages seemed to be the best, especially in the case of small consignments to private individuals.
4. The packages most likely to be useful at Quetta appeared to be (a) non-returnable peach crates with 3" and 3½" chip cubes for the five seer railway rate. (b) Grape boxes suitable for the 2½ and 5 seer rates. (c) Non-returnable and returnable crates holding 24 chip baskets, each holding about one seer, the whole coming under the 30 seer rate. (d) Cheap climax baskets for selling fruit at the markets and at the various gardens.
5. The best packing material appeared to be *sun*n fibre imported from Oudh in pressed bales. This was cheaper and better than cottonwool and also easier to handle than wood wool which also received an extended trial. Care must be taken to use only clean well-retted *sun*n for this purpose.

During the present year a supply of these packages likely to be of most use in Quetta was made to order by the British Basket Company of Glasgow and shipped to Karachi. They were placed on the market at Quetta and sold at prices sufficient to cover all expenses including that connected with their sale. All the packages were taken up by the Indian fruit traders and about half the supply imported was sold. In all about £45 worth was supplied to the trade. It is expected the rest will be disposed of

next year and that the expenses connected with the importation will be completely recovered.

Experiments on the transport of grapes were taken up on a small scale in 1912 and it was found possible to send these to Calcutta packed with *sunn* in the non-returnable crates. The prices realized were Rs. 2 per seer which gives a very good return. Unfortunately the supply of cork dust ordered for the grape packing experiments did not arrive in time, but it is hoped to carry out tests with this material later on.

As a result of the experiments of 1911 and 1912 it may be said that most of the fruit packing questions have been solved and that packages better and cheaper than anything to be produced locally have been brought to the notice of the trade. For a year or two it will be necessary for Government to finance the supply of these packages after which it will be best to get an agency established in Quetta and for the trade to supply itself. Mr. Bliss has agreed to take up the agency when the time comes.

Future Work.

As most of the initial difficulties connected with the scheme have now been overcome and a beginning has been made with the work, it is not out of place to indicate the lines of future progress and to sum up the present position. The prospects of success of the fruit scheme are exceedingly favourable and there appears to be no reason why the project should not fulfil the expectations of its promoters. As results accumulate and as the water-saving devices become known, there is no doubt that the lessons of the experiment station will be taken up at once. The present methods are haphazard and all that is done after the planting of the trees is to apply water in the most wasteful method that could be devised and take whatever crop happens to be produced. None of the zemindars realize the possibilities of the valley and there is no doubt that an area under fruit and other crops properly managed would revolutionise the present practices. What is possible in

the valley has been clearly indicated by the tomato experiment of this year and equally striking results are possible with other fruit crops. What is wanted is the application of scientific principles to crop production and the only way of doing this is for Government to continue to act as the pioneering agency and to show the way.

As regards the future the following are the chief lines of work which remain to be developed :—

1. *Propagation*.—More attention will be necessary in the raising of young trees for planting. A greater range of stocks is desirable and the trees should be trained while in the nursery. A large selection of kinds should be raised so as to prolong the season of each fruit and the losses to the Province in the past from the distribution of bad stock should be prevented in the future.

2. *Improvement in yield and quality*.—Great advances in the yield and quality of fruit are necessary before the industry can be developed. At present the yield of fruit per acre is very small and the quality is not good. Varieties which require good cultivation like peaches are very short-lived and the prevalence of the yellowing of the leaves indicates that these trees are not properly grown. Pruning is hardly understood at present and the trees carry only a small proportion of poor fruit compared with what is easily possible.

3. *Water conservation*.—The great need in agriculture in Baluchistan is the saving of water. In this connection the preliminary work which has been done on surface cultivation, furrow irrigation and the increasing of the water-holding capacity of the soil by green manuring should be developed and the possibilities of water-saving demonstrated by actual examples.

4. *Vegetable growing*.—Good vegetables can be grown at Quetta at a time when there are no supplies to be had in the plains. It has been demonstrated that tomatoes can be sent to Calcutta at a good profit and there is little doubt that this line of work can be extended considerably in the future.

5. *Fruit packing*.—The work on fruit packing should be continued, particularly with regard to grapes for which there is likely to be a great demand in India at good prices. Moreover, grapes grow well in Baluchistan and appeal to both Europeans and Indians in Hindustan. The importation of packages should be supervised for a year or two until the trade is in a position to supply itself. Possibly later on cool vans will be available for the Calcutta market and whole van-loads can be sent to that city.

6. *Collection of varieties*.—The work on the collection of the best indigenous varieties together with good kinds from France and the United States should be continued till the experiment station is really well stocked. The best of these trees should be propagated and the young trees made available to the public.

7. *Training*.—In addition to the purpose of the experiment station as a model for the Province it can easily be made use of as a training ground for *malis* and *zemin-dars*. The object aimed at should be to pass a number of men every year through the station and to train them in all branches of the work. In this way the standard of agriculture will gradually rise and fruit-growing will be placed on a higher plane. Detailed proposals on this subject are being submitted to the Local Administration.

VI.—PROGRAMME AND PUBLICATIONS.

Programme of work for 1913-14.

1. *Training*.—The training of advanced students in this section will be continued.

2. *Plant breeding and plant improvement*.—During the year the following crops will be studied:—wheat, tobacco, oil-seeds, fibre plants and indigo.

(a) *Wheat*.—The production of improved and rust-resistant types by selection and hybridisation will be continued. The co-operative experiments on the influence of the environment on the milling and baking qualities of Indian

wheats, which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, will be continued. The botanical survey of the wheats of Baluchistan and the agricultural survey of the wheats of Bihar will be completed.

- (b) *Tobacco*.—The production of new varieties by selection and hybridisation will be continued, as well as the testing and curing of the varieties already isolated. The detailed study of the inheritance of characters in tobacco is being continued by the Personal Assistant.
- (c) *Oil-seeds*.—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.
- (d) *Fibres*.—The isolation and testing of pure races of the fibre plants of India will be continued. The study of the inheritance of characters in these crops is being continued.
- (e) *Fruit*.—The fruit experiment at Pusa will be continued on the lines laid down in the first Fruit Report. During the months May to September the work connected with the development of the fruit industry of Baluchistan will be continued.

Publications.

Some progress was made in the publication of results and a certain number of completed pieces of work were written up during the year. A good deal, however, remains to be done to bring the publication of results up to date.

The following papers were written or published during the year :—

1. Some Aspects of the Agricultural Development of Bihar. *Bulletin No. 33, Agricultural Research Institute, Pusa.*
2. The cultivation and transport of tomatoes in India (with G. L. C. Howard). *Bulletin No. 1, Fruit Experiment*

- Station, Quetta.* (Reprinted in the *Agricultural Journal of India*, Vol. VIII, Part III.)
3. Some improvements in the packing and transport of fruit in India (with G. L. C. Howard). *Bulletin No. 2, Fruit Experiment Station, Quetta.* (Reprinted in the *Agricultural Journal of India*, Vol. VIII, Part III.)
 4. The improvement of crops (with G. L. C. Howard). *Agricultural Journal of India*, Vol. VIII, Part II.
 5. Yield and quality in wheat (with H. Martin Leake and G. L. C. Howard). *Agricultural Journal of India*, Vol. VIII, Part II.
 6. Natural root-grafting. *Agricultural Journal of India*, Vol. VIII, Part II.
 7. The improvement of Indian wheat—a paper read at the Punjab Agricultural Conference, Lyallpur, November 4th, 1912 (with G. L. C. Howard). *Agricultural Journal of India*, Vol. VIII, Part I.
 8. Sesam, *Sesamum indicum*, L. *Die Züchtung der landwirtschaftlichen Kulturpflanzen*, Bd. V, Paul Parey, Berlin, 1912.
 9. Deccan-order Ambari-Hanf (*Hibiscus cannabinus*, L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen*, Bd. V, Paul Parey, Berlin, 1912.
 10. Hibiscus Sabdariffa, L. *Die Züchtung der landwirtschaftlichen Kulturpflanzen*, Bd. V, Paul Parey, Berlin, 1912.
 11. Indischer Sunn-Hanf (*Crotalaria juncea*, L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen*, Bd. V, Paul Parey, Berlin, 1912.
 12. Kugelfruchtige Jute (*Corchorus capsularis*, L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen*, Bd. V, Paul Parey, Berlin, 1912.
 13. Langfruchtige Jute (*Corchorus olitorius*, L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen*, Bd. V, Paul Parey, Berlin, 1912.
 14. Studies in Indian Tobaccos. No. 3. The inheritance of characters in *Nicotiana tabacum*, L. (G. L. C. Howard). *Memoirs Department of Agriculture in India* (Botanical Series), Vol. VI, No. 3.
 15. On the inheritance of some characters in wheat—I (with G. L. C. Howard). *Memoirs Department of Agriculture in India* (Botanical Series), Vol. V, No. 1.

REPORT OF THE IMPERIAL MYCOLOGIST

(E. J. BUTLER, M.B., F.L.S.)

I.—CHARGE AND ESTABLISHMENT.

I was on privilege leave for the first six days of the year, since when I have remained in charge of the section. Mr. F. J. F. Shaw continued to hold the post of Supernumerary Mycologist until April 21st, when he left to take up his acting appointment as Government Mycologist, Madras. He was confirmed in the service during the year. Mr. J. H. Mitter, Second Assistant, officiated as Assistant Professor of Botany in the Agricultural College, Lyallpur, until the end of August when he was appointed Assistant Professor of Botany, Muir Central College, Allahabad. The vacancy thus caused was filled by promotion in order of seniority, S. Pasupati Iyer coming in as Second Clerk. All the staff have worked well.

II.—TRAINING.

Babu K. C. Banerji, B.A., L.Ag. (Nagpur), a stipendiary student from the Agricultural Department, Bihar and Orissa, was under training until August 17th.

III.—DISEASES OF PLANTS.

The investigation of diseases of plants caused by fungi, and the more routine work of dealing with enquiries regarding the identity and treatment of crop diseases, formed, as usual, the greater part of the work of the section.

(1) *Rice diseases*.—The disease of this crop in Eastern Bengal, locally known as *ufra*, has assumed serious proportions. The districts known to be affected are Noakhali, Tippera and Dacca. In these districts paddy is the staple food crop, occupying over 70 per cent. of the cultivated area or some $2\frac{1}{2}$ to 3 million acres, with an outturn of about

1,100,000 tons of clean rice. Both the main winter crop, or "aman," paddy and the autumn, or "aus," crop suffer, but the damage is much greater in the former, as its long growth period allows of a progressive increase of the parasite. The most severely attacked varieties are those grown in the lower lands, subject to early inundation and where transplantation is not possible. A large part of the rice grown is of this class; the transplanted varieties, grown on higher land, occupy a smaller area and do not seem to get the disease. The lower land is under water for a considerable period every year and gets little cultivation, being often allowed to remain covered with weeds and stubble after harvest until the first spring showers. The organism, an eelworm of the genus *Tylenchus*, mentioned in last year's report as the suspected cause of the disease, has been found during the year to be constantly present in every case and attempts to induce the disease experimentally by inoculating healthy paddy with it have been fully successful both at Pusa and at Dacca. The worm is one previously undescribed and, up to the present, has been found only on paddy suffering from *ufra*, or in the stubble from the diseased crop. On the living plant it is active, feeding and reproducing freely; after the death of the plant it assumes a passive condition, lying coiled up within the sheaths and glumes, and in this state can remain alive, if kept dry, for many months. Activity is resumed, at Pusa, about April. The length of the life cycle is not yet known, but there are several generations during the growth period of the crop and the rate of multiplication appears to be very considerable.

Experiments have been undertaken, in collaboration with the Bengal Department of Agriculture, to devise methods of fighting this disease. Paddy probably suffers less than any other cereal from epidemic diseases and every effort will have to be made to check the spread of *ufra*. The losses caused by it are very great; in some cases the crop is not worth harvesting, in many others it is reduced to half or a quarter of the normal. In the districts referred

to nothing else can replace paddy as a food crop, and in certain parts the distress that has been caused is undoubtedly very great. The most hopeful method of attack appears to be the destruction, by burning, of the stubble from diseased fields, and the Bengal Department has arranged to expend a considerable sum in experiments in this direction. A small area has been selected near Comilla for further experiments, especially in cultivation and trial of varieties. The enquiry will be treated as the most important on which this section is engaged, and efforts will be made in particular to fill up the gaps in our knowledge of the life history of the parasite. An account of the work up to date has been included in a Bulletin on rice diseases, now in the press, and a less technical paper has been contributed to the Agricultural Journal.

Amongst other diseases of rice investigated during the year, "bunt" (caused by *Tilletia horrida* Tak.) was found to be widely prevalent in Burma, though usually in such small amount as to cause little loss. Its detection was the result of complaints received from Germany, of the presence of black spores in rice meal imported from Rangoon and Moulmein. The disease is one which may well increase in virulence as time goes on and it is useful to know that we have a safe and assured preventative in a seed steep, similar to one employed against the allied wheat bunt.

The false smut of rice [caused by *Ustilagoidea virens* (Cke.) Tak.] was found to occur throughout a large part of the rice-growing tracts of India. It does rather more damage than bunt, but still not enough, usually, to repay treatment. This is fortunate, for no treatment is known, and experiments to follow out the life history of the fungus and ascertain how it infects the host plant have failed. These experiments will be continued as opportunity offers.

Probably more important than either of the two last mentioned diseases is that caused by *Sclerotium Oryzae* Catt., which I found in Burma and Madras and which also occurs at Pusa. Its symptoms are obscure and it can

easily be overlooked, as its chief effects are to cause excessive late tillering of the plant and partial sterility of the ear. Its further investigation was taken up by Mr. Shaw, who has established the parasitism of the fungus and studied its behaviour in artificial culture. The disease is probably one of the causes of the condition known in Burma as *gua-bo*, in which an undue proportion of the ears are light or partially sterile and which is said to represent a very great aggregate loss. I found on local examination that most of the loss was attributable to insect pests, chiefly borers, and that fungus injury was probably too slight to be of economic significance. Mr. Shaw has prepared an account of his investigation, which is in the press as a Memoir.

(2) *Sugarcane diseases*.—The “red rot” of sugarcane (caused by *Colletotrichum falcatum* Went.), which is the worst fungus disease of this crop in India, has been under study at Pusa for a number of years. Various difficulties which were met with have delayed the writing up of the results, but sufficient information has now been obtained to justify publication. A Memoir, prepared jointly by myself and A. Hafiz Khan, Third Assistant, to contain the results of experimental work since 1906, has been submitted for publication. The experiments have been chiefly directed to obtain information as regards methods of infection. It has been securely established that the most common method in Northern India is by the planting of infected setts from a previously diseased crop, a method that has been recently controverted in Louisiana and the West Indies. The failure of sett selection which has been observed on several occasions, has been shown to be due to the presence, in severely diseased crops, of a percentage of infected canes which do not show the characteristic warning symptom of reddening in the pith. In attacks of ordinary severity this percentage is negligible, but in severe epidemics it is advisable to avoid the use of any cane from the diseased crop for seed. It has been further shown that sound setts may be infected after planting, though in

Northern India the parasite appears to die out rapidly in the soil and there is not much danger from this source, unless there is carelessness in allowing rotten canes to lie on the fields after harvest. Infection by air-borne spores through wounds in the stem, such as those caused by boring insects, was found to be uncommon, though accepted as the usual method in most other countries where the disease is prevalent. The leaf scars at the joints, left after the leaves are removed in stripping or wrapping the cane, are stated by some observers to admit the parasite, but it was found that this did not occur if the leaf had reached maturity and came away readily. On the other hand the shoot and root eyes at the joints can be infected and through the latter, especially, the fungus has no difficulty in gaining an entry into the cane pith. The most probable origin of the infective matter was found to be a form of the fungus which is parasitic on the midrib of the leaf, and which had been overlooked by most observers.

From these results, backed by field observations, it is concluded that the most important precaution to be taken against the disease is to select the setts used for planting, so that only those with unreddened pith are used. The effect of sett selection in keeping the disease from reaching epidemic severity has been very satisfactory in several Bihar estates and elsewhere, and it should be made a routine practice. In very severe attacks sett selection may fail, and it may be necessary to introduce new seed from outside. Care must be taken at the same time to remove early cases of the disease, in order to avoid risk of infection through the shoot and root eyes, and also to destroy rotten canes and trash after harvest, so as to prevent infection of the setts at or after the time of planting. Finally it is pointed out that the "thin" canes, in which India is so rich, are almost immune to the disease; that the comparatively little damage caused by red rot in Java may be due to the fact that many of the best Java canes are the progeny of crosses between Indian thin canes and the locally grown thick kinds; and that there is every

reason to hope that similar results can be obtained in India by hybridization.

Three minor sugarcane diseases, caused by undescribed species of fungi, have also been under study, and the work was advanced sufficiently by the end of the year to allow of the results being written up. One of these, occurring at Samalkota and Jorhat, is possibly that referred to in last year's report as resembling *sereh*. They will be more fully dealt with in the next report.

Phytophthora investigations.

Mr. J. F. Dastur, First Assistant, completed his investigations of a new species of this destructive genus, which was found attacking castor, and published a detailed description of it in the Memoirs. The parasite causes the most injurious fungal disease of this crop known, and is especially harmful to eri-silk worm breeders. On seedling plants it causes a "damping off," which may affect 30 to 40 per cent. of the seedlings; older plants are attacked chiefly in the leaves. A full account of the morphology of the parasite is given, the chief interest centring in the discovery of a new type of reproduction. Shortly before the publication of the paper, this discovery was anticipated by a British Mycologist, working with an allied species. The growth of the fungus in artificial culture was successfully attempted. A very complete series of inoculation experiments was carried out, potato, tomato, brinjal, *til* and several other plants proving susceptible to attack.

The study of *Colocasia* blight (caused by *Phytophthora Colocasiæ* Rac.) was commenced by Mr. G. S. Kulkarni, Mycological Assistant of the Bombay Department, when a student at Pusa in 1909, and completed by myself during the year. We published a joint account of it in the Memoirs, giving details of the characters of the disease and the morphology and biology of the fungus. The intensity of the attack is closely dependent on the character of the monsoon, being worst in wet years. In addition to the already known damage caused by rotting the leaves, the

parasite was found to infect the corms and to cause considerable injury after the crop is lifted. Pure cultures were grown in 1912, and a large series of inoculation experiments carried out, but the species is much more restricted in its choice of hosts than the castor parasite.

A serious outbreak of potato blight (caused by *Phytophthora infestans* de Bary) occurred in the Gangetic Plain, where the disease has not been reported since 1902. The outbreak is probably to be attributed to the fact that the local seed supply failed, in a great measure as a result of damage caused by the potato moth. A large import of hill seed occurred at the beginning of the cold weather and no doubt introduced the fungus, which is endemic in the hills. Mr. Dastur has obtained pure cultures of the parasite and is testing its temperature relations, as this appears to be likely to prove the most important factor in its control.

Rhizoctonia.

The results of Mr. Shaw's work on this genus of soil-dwelling parasites, referred to more fully in last year's report, were published during the year. He has continued his investigations, particularly with forms parasitic on lucerne and Delphinium. It is evident that great confusion of species exists in the published literature of the genus and his researches should do much to clear this up. It is of interest to record that a severe attack of opium poppy blight, which has generally been supposed to be caused by *Peronospora arborescens*, was found to be due last season to *Rhizoctonia*. It is hoped that Mr. Shaw will be able to continue his work on this, after his return from Madras.

Wheat rust.

Wheat rust was prevalent in Bihar last season and some interesting observations were made in selected areas at Pusa, on the influence of soil moisture and density of growth on the disease. Orange rust (*Puccinia triticina*)

appeared early and spread uniformly, without much relation to position in the field or density of the crop. Later on it became more intense where the crop was heaviest and tallest, but was soon masked by yellow rust (*Puccinia glumarum*). This did not appear in any quantity until the crop was nearly full grown but then developed with great intensity wherever the crop was tall and dense. Black rust (*Puccinia graminis*) was late in appearing and did not show any regularity in distribution. In February and March, Dr. Leather kindly made some determinations of soil moisture and air humidity in two plots, one with a light, thin crop where rust was slight, and the other where the crop was heavy and rust severe. The soil moisture was much better in the latter, especially from the 3rd to the 6th foot in depth. The humidity was taken within the crop, about 4 inches above ground level, the first test, lasting for 7 to 8 hours, being made on February 14th, in dull and humid weather. In the thin crop the relative humidity was 57.3 per cent. and the mean air temperature was 26° C. In the heavy, badly rusted crop, the relative humidity was 76.7 per cent. and the mean air temperature 23° C. A second test was made on February 21st, the crop having been much laid by a storm on the 15th and the day being fine with a dry west wind blowing. No appreciable difference was found in the two plots.

The intensity of the attack of yellow rust and the later stages of orange rust thus varied directly with the soil moisture and the air humidity within the crop. The early stages of orange rust would not be exposed to the influence of the latter factor, as at that period the crop is too small to cover the ground closely. By the time black rust appears, transpiration has much diminished, as the crop is then almost ripe; the air temperature is higher and the drying west winds have usually set in. Hence the late rust is not much exposed to differences in air humidity. Of the two factors the immediately important one is apparently the humidity of the air within the crop, but

this again is connected with the soil moisture, as it must depend largely on the density of the crop and the vigour of transpiration.

Ground-nut diseases.

The cultivation of ground-nut in the Bombay Presidency underwent a progressive decline between 1895 and 1903. This decline was attributed in 1902 by Mr. Mollison, then Inspector General of Agriculture, to the extension of disease in the crop. In that year I found a fungal disease (caused by *Septoglœum Arachidis* Rac.) was doing great damage. Attempts to check it by spraying failed, and the only hope seemed to lie in the introduction of early maturing and resistant varieties. Recently the cultivation of ground-nut has again expanded and various reports led me to believe that this disease had diminished. On visiting the Presidency I found that this was the case to such a degree, that I had considerable difficulty in finding any attacked plants. Coincident with the decline of the disease there has been a change in the varieties of ground-nut grown. The Bombay Department of Agriculture introduced a number of foreign varieties in 1901 and the following years, and these have almost replaced the old varieties, except in the Poona District. It is difficult to avoid the conclusion that the introduction of the new varieties is connected in some way with the decline of the disease, though a direct connection is hard to establish, since the old varieties, still grown near Poona, are now equally free from attack. It would, however, be interesting to know how far natural crossing has occurred between the new and the old varieties, as in this there is a possible explanation of the difficulty. I think that Mr. Mollison and the Bombay Department are entitled to claim the credit of having successfully fought one of the worst diseases of cultivated crops which I have seen in India. The area under ground-nut in the Deccan rose from 56,000 acres in 1902-03, to nearly 200,000 acres in 1911-12.

Cotton and Sesamum wilts.

A wilt disease of cotton (caused by *Fusarium vasinfectum* Atk.) is probably the worst fungal disease of this crop in the United States and has been reported from most other cotton-growing countries. It has been known for some years that a similar disease occurs in the Central Provinces. Sesamum is also attacked by an allied disease, and an attempt was made to isolate the parasites concerned, establish their identity and make as complete a study of the diseases as possible. I found cotton wilt extends over a large area from the Central Provinces to Belgaum, being especially prevalent in the Berars, where it has been carefully observed by Mr. Clouston. Sesamum wilt extends from Hoshangabad, where Mr. Evans gave me much useful information regarding its distribution and field characters, into parts of Bombay. Fungi of the genus *Fusarium* were isolated from both crops and have been maintained in pure culture. The first attempts to test their parasitism failed, possibly because the season was already too far advanced, and the work is, consequently, being repeated.

Anthraxnose of Sisal hemp.

This disease was investigated by Mr. Shaw, who established the parasitism of the fungus (*Colletotrichum Agaves* Cav.) previously suspected to be its cause. It was found to infect species of *Agave* readily and to produce a characteristic leaf disease. An account of the work was published in the Agricultural Journal of India, January 1913. Collecting and burning diseased leaves, and spraying with Bordeaux mixture, are measures which are recommended as likely to prove efficacious in checking the disease.

Indigo disease.

The work mentioned in last year's report was continued, but led to no useful results. Neither Mr. Shaw nor myself, working independently, was able to obtain any evidence that the so-called disease is caused by any definite parasite. Some half a dozen species of fungi were isolated from

plants in various stages of "disease," but none of these proved capable of reproducing it. As they were mostly belonging to the class of weak parasites, capable of infecting the host plant only when the latter has been weakened by some other agency, it was concluded that the cause of the trouble lies deeper. Since it is practically certain that it is not mycological, the enquiry was abandoned, and a note giving a summary of the work, and the reasons for this step, was submitted to the Bihar Planters' Association, and circulated amongst the members.

Forest tree diseases.

This section, as usual, assisted the Forest Department in examining and reporting on specimens of fungus diseases of forest trees, mostly received through the Imperial Forest Botanist. As this is rather a specialised branch of mycology and as the work of the section has grown too much to allow of all enquiries being dealt with equally fully, arrangements were made with the Forest Botanist, defining what assistance we were prepared to give. Under present circumstances, it will not usually be possible to undertake any definite research into the causes of undescribed diseases of trees, but where the parasite is already known, or is allied to known ones, assistance can be given. The Forest Botanist was supplied with all the information available in this section on the obscure "spike" disease of sandal.

Green parasites.

Mr. Shaw continued his investigation of the flowering plant *Striga*, which is parasitic on the roots of jowar, sugarcane and other *Gramineæ* in India. He also took up the study of an allied plant, *Sopubia*, which attacks several cereals. When the work was commenced, little was known regarding these interesting plants, but the result of work on South African species of *Striga* has recently been published. It is still necessary to compare the Indian species

with those of South Africa and the investigation of *Sopubia*, about which nothing whatever is known, is equally important. The economic aspect has not, as yet, been considered in South Africa, and this side of the enquiry is of primary interest to us.

Other plant diseases.

The section has, as usual, been consulted by the Scientific Department of the Indian Tea Association on several occasions. It was also consulted by the Australian Prickly Pear Commission, on the diseases of that plant in India, and by the Agricultural Department of British East Africa, on coffee leaf disease. A serious disease of betle pepper, which causes great loss in certain parts of India, is being investigated and appears to be caused by an undescribed species of *Colletotrichum*, of which the perfect stage has been obtained in culture. Experiments in checking anthracnose of plantains were continued. The treatment of oat smut by formalin steeping was successfully demonstrated on several estates in Bihar, and is being taken up satisfactorily. Work with *Pennisetum* smut was continued, but the life history of the fungus has not yet been worked out. A disease of maize, hitherto unknown outside Java, appeared at Pusa last year. It is exceedingly destructive in Java, but our knowledge of the life history of the parasite [*Sclerospora Maydis* (Rac.) Butl.] is imperfect and an attempt was made, and is being continued, to obtain fuller information on this point. An account of it was published in the Memoirs. The "damping off" of seedlings (caused by *Pythium de Baryanum* Hesse) was found for the first time in India last year, though common in temperate climates. Its study in culture was undertaken, and an account of it published in the Memoirs. The rotting of stored potatoes is being investigated at the instance of the Economic Botanist, Bihar and Orissa; much of the loss has been found to be due to *Rhizoctonia*.

IV.—SYSTEMATIC WORK.

The additions to the herbarium continued steadily, the total number of mounted sheets added being 780. Most of these were Indian, the most important outside contributions being from Berlin and Manilla. A considerable number of parasitic fungi were named for the college collections of the Provincial Departments of Agriculture, for other colleges, and for the Forest Research Institute. Large collections of Indian fungi were distributed to interested persons. The *Hypocreaceae* of our collections were kindly named by Mr. T. Petch, Government Mycologist, Ceylon. The perfect stages of the rusts of sugarcane, cotton and fig were discovered during the year and will be described shortly. Mr. Shaw has commenced the systematic study of some soil fungi.

V.—PROGRAMME OF WORK FOR 1913-14.

(1) *Research and experimental work*.—The continued investigation of the disease of paddy, known as *ufra* in Bengal, will be regarded as the most important individual item of the work of the section. Other diseases of paddy will be studied as occasion arises.

Of sugarcane diseases, the study of which will be continued, the most important in view is the *sereh*-like disease at Jorhat and elsewhere. It is hoped to ascertain definitely whether it is caused by a fungus, and, if so, whether it is identical with a new disease of which an account will shortly be published.

The wilt diseases of cotton and sesamum are major diseases, the investigation of which will be continued.

The work on potato blight may also require to be treated as an investigation of importance, if the disease again recurs, and the same applies to the opium poppy blight, referred to in the body of the report.

Besides the investigation of the last-mentioned disease, Mr. Shaw may be able, on his return from Madras, to progress with his study of some green parasites, of which

a more precise knowledge than is at present available is greatly required. His work on soil fungi is likely to extend over a considerable period and is not of such immediate importance as the other enquiries, but it probably has a bearing on such questions as the decomposition of green manures, and may give valuable results.

Minor investigations are those of the anthracnoses of plantain and betle pepper, smut of *Pennisetum*, maize mildew and further work on diseases of castor.

(2) *Training*.—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(3) The routine work of advising on plant diseases will be continued and assistance will be given as usual to the Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

(4) It is hoped to make further progress with the publication of descriptive lists of Indian fungi, and, if time permits, the preparation of a 5th part of "Fungi Indię Orientalis" will be taken up. This will be the most important item of the systematic work.

VI.—PUBLICATIONS

1. Preliminary Report on Ufra disease of Rice in Noakhali District. E. J. Butler. *Bull. of the Bureau of Agricultural Intelligence and of Plant-diseases*, 3rd year, No. 7, July, 1912. p. 1661.
2. The Morphology and Parasitism of *Rhizactonia*, F. J. F. Shaw. *Mem. Dept. of Agri., Bot. Ser.*, IV, No. 6, September, 1912.
3. Anthracnose of Sisal Hemp, F. J. F. Shaw. *Agri. Journ. of India*, VIII, No. 1, January, 1913.
4. Report on Mycology for 1911-12, E. J. Butler. *Annual Report of the Board of Scientific Advice*, April, 1913.
5. On *Phytophthora parasitica* nov. spec., a new disease of the Castor oil plant, J. F. Dastur. *Mem. Dept. of Agri. India*, Bot. Ser., V, No. 4, May, 1913.

6. Colocasia blight, caused by *Phytophthora Colocasiæ* Rac., E. J. Butler and G. S. Kulkarni. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 5, May, 1913.
7. *Pythium de Baryanum* Hesse, E. J. Butler. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 5, May, 1913.
8. The Downy Mildew of Maize [*Sclerospora Maydis* (Rac.) Butl.], E. J. Butler. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 5, May, 1913.
9. Diseases of Rice, E. J. Butler. *Bull. 34, Agri. Res. Inst., Pusa* (*in the press*).
10. Ufra disease of Rice, E. J. Butler. *Agri. Journ. of India*, VIII, No. 3 (*in the press*).
11. A Sclerotial disease of Rice, F. J. F. Shaw. *Mem. Dept. of Agri., India*, Bot. Ser., VI, No. 2 (*in the press*).
12. Red Rot of Sugarcane, E. J. Butler and A. Hafiz Khan. *Mem. Dept. of Agri., India*, Bot. Ser., VI, No. 5 (*in the press*).

REPORT OF THE IMPERIAL ENTOMOLOGIST

(A. J. GROVE, M.Sc.)

I.—CHARGE AND ESTABLISHMENT.

I held charge of the section from July 1st, 1912, until the 29th, when Mr. H. Maxwell-Lefroy, Imperial Entomologist, returned from leave. Mr. Lefroy, however, resigned his post on the 30th of November 1912 and I took over charge from him on that date to officiate under orders of the Government of India until a new appointment was made, and have continued to hold charge since then. The First Assistant, Mr. C. S. Misra, was away on privilege leave from January 2nd until April 2nd, 1913. He has continued to be in charge of the field work on the Pusa Farm and the Botanical area, and has also instructed the long course students. The giving of two short courses in Lac Cultivation and the arranging of the general lac work has been in his hands. As well as this routine work, he has undertaken investigations on the occurrence of bollworms and their parasites in the experimental plots on the farm, arranging for the despatch of parasites to Egypt, and has also continued his work on economic *Aleurodidae* and *Coccidæ*. The Second Assistant was on privilege leave from the middle of November to the end of December. He has remained in charge of the Insectary and assisted in the special investigation on indigo "Psylla." He has also done much useful work with the European and Indian bees. Mr. Dutt was on privilege leave from January 2nd to March 2nd, 1913. He has remained in charge of the economic collections and correspondence, a part of the General Collection (*Hymenoptera*), and the preparation and distribution of coloured plates and lantern slides, and has taken up a study of Hymenopterous parasites of crop pests. Mr. D. Nowrojee took privilege leave for 18 days during October and November 1912. He has remained in charge of the General Collections and has continued in-

vestigations on the biology of beetles affecting stored products. Mr. M. N. De has continued in charge of the Silk House and has carried out the hybridisation work with Mulberry silkworms and has also assisted in the preparation of sample silk pieces with both Eri and Mulberry Silk.

II.—TRAINING.

The private student deputed by the Department of Agriculture, Travancore, continued his training until March 14th when he returned to his State for three months to study the particular pests of the State and returned on July 4th to work up the material he had collected and to continue his training. A student, deputed by the Assam Department of Agriculture, was admitted on November 1st, 1912, for training. A student from the Agricultural College, Giza, Egypt, was admitted on August 1st at the request of the Government of Egypt for a three months' training in practical entomology. Nine students have attended the short courses in Sericulture. Seven students attended the two short courses in Lac Cultivation, five in June and two in October.

III.—RESEARCH.

The investigation into the so-called "Psylla" disease of indigo was carried on and the practical results have been published. General enquiries into the biology and habits of insect pests have been continued and among those studied may be mentioned Painted Bug, Anar Butterfly, Termites (White-ants) and Bollworms and their parasites. An investigation has also been commenced, at the request of the Punjab Government, into methods for preserving wheat stored in bins from damage by beetles.

IV.—INSECT SURVEY.

Additions have been made to the general collections during the year. Specimens of *Orthoptera* sent to Mr. Kirby, *Homoptera* to Mr. Banks, *Ichneumonidæ* to Mr.

Morley and *Psyllidæ* to Mr. Crawford for identification have been received back. Specimens of *Coleoptera* (*Longicornia*) were sent to Mr. Gahan and *Cantharidæ* to Dr. Wellman for identification.

V.—PROVINCIAL WORK.

With the appointment of Entomological Assistants to the Provinces, Pusa is less in touch with the work done in the Provinces except in such cases where the Entomological Assistants submit monthly reports and where direct guidance is asked for. Also with the appointment of a European Entomologist to the Government of Madras, the necessity for controlling the work in that Presidency from Pusa no longer exists. It is to be regretted that Pusa is not in closer touch with the provincial work and the matter is under consideration, for it is advisable that there should be as complete co-ordination of the entomological work in India as possible in order to prevent duplication.

In the Central Provinces the rearing of Eri worms was continued and an effort was made to study sugarcane borers and the effect of growing maize as a trap-crop for them. In Bihar and Orissa the campaign against the greasy Cut-worm, *Agrotis ypsilon*, was successfully carried out. Arrangements were also made to make more traps locally and to start work against the Cut-worm at Bhagalpur and Colgong during the following year. Potato storage experiments were made at Bettiah, Bihar, Bhagalpur and Colgong, and demonstration godowns were started at Colgong and Bhagalpur. The rearing of Eri worms was continued and eggs were distributed to the local zemindars. In Baroda, work on checking the "Katra" and the sesamum stem-borer was continued. Field demonstrations were also given in several villages to check cotton bollworms, the sesamum stem-borer and the tobacco stem-borer. Arrangements were also made to start lac cultivation on *Babool* in the State and to procure *Babool* brood-lac locally.

VI.—SPECIAL INVESTIGATIONS.

(1) *Insecticides*.—Various proprietary preparations have been received for trial and reported upon. Many of these are found either to fall short of what is claimed for them or to be unsuitable for use in India.

(2) *Sericulture*.—The experiments with European Univoltine races have been continued and have given satisfactory results. The eggs which, as reported last year, were sent to places in the hills, where the temperature is not so extreme as on the plains, for storage during their dormant period, have turned out very well and given as good results as those which were cold-stored in a refrigerator in Calcutta. The hybridisation work with mulberry worms has been continued and more satisfactory results have been obtained.

Eri silkworms were again reared with good results, except during the hot dry months when conditions are extremely unfavourable. With this industry there is great need for better organisation both with regard to the distribution of seed and the disposal of cocoons. Efforts have been made to make arrangements whereby small rearers can dispose with advantage of the small quantities of cocoons they produce, but much closer co-operation among the rearers will be necessary before this can be done satisfactorily. The necessity, too, of a certain supply of reliable eggs has been felt this season and it is hoped that arrangements to overcome this difficulty may be made in future.

Requests for mulberry and castor seeds, disease-free Mulberry and Eri eggs, samples of cocoons, yarn, cloth, pamphlets, etc., have been received from numerous applicants, whose requirements have been supplied as far as possible. Sample pieces of both Eri and Mulberry silk cloth have been prepared and dyed with alizarin colours to show Indian weavers the possibilities of these silks.

Exhibits were sent to Muzafferpore, Bankipur, Malda, Banjettia, Ellore, Calcutta and Bangalore.

(3) *Lac culture*.—Two short courses in lac cultivation were given. The collection of lac insects from Forest

Officers for the determination of the species of lac insects has been continued and the series from most ranges are now almost complete. *Ber* and *Kusumb* plants, inoculated with lac insects, were again sent to Japan. Brood-lac was sent to Ceylon. Numerous enquiries about lac cultivation were received and answered. The Bulletin on the "Lac Cultivation in the Plains of India" is being translated into Hindi and Urdu. Experiments to determine other food-plants of the *Ber* lac have been carried out and are still in progress.

(4) *Apiculture*.—The experiments with European bees have been continued, but this year particular attention has been directed to obtaining fertilized queens. A large number of experiments were made and in all twenty-five queens were reared, but of these only two were successfully fertilized. Although this result seems rather poor, a large amount of valuable experience was obtained and it is hoped that when the proper season again comes round more successful results will be obtained.

The experiments with the Indian bee, *Apis indica*, were continued, but much progress was still impossible owing to the lack of suitable appliances. A foundation mill has now been obtained and it is hoped that during the next honey flow a satisfactory test of their honey-gathering qualities will be made.

VII.—DEMONSTRATION.

Owing to lack of funds no new coloured plates were issued during the year. Additional copies of the plates already published were issued to the Directors of Agriculture, Bengal and the Central Provinces, and to the Principal, Agricultural College, Nagpur. Sets of coloured lantern slides were supplied to the Director of Agriculture, Bengal, Principal, Agricultural College, Nagpur, Entomological Assistant, Baroda State, and the Assistant Professor of Entomology, Agricultural College, Lyallpur. The Department of Agriculture, Bombay, have indented for a large supply of coloured plates and arrangements have been made to supply these.

A demonstration of the use of spraying machines was given at various Indigo Factories in Bihar in connection with the treatment of indigo "Psylla."



VIII.—CORRESPONDENCE.

Much time is still devoted to dealing with the numerous applications received for information, advice and the like, in the many branches of entomological endeavour dealt with by this section, but such correspondence is still given the greatest possible attention because of its great utility to officials and the general public. Eighty parcels of specimens were received from various applicants during the year and the fullest information possible was supplied in each case.

IX.—VISITORS.

The Hon'ble Sir K. G. Gupta, K.C.S.I., Member of the Secretary of State's Council, and the Hon'ble Sir Charles Bayley, K.C.S.I., Lieutenant-Governor of Bihar and Orissa, visited the section in November and January respectively. Dr. L. H. Gough, Entomologist to the Department of Agriculture, Egypt, worked in the Laboratory in September and visited Baroda and Cawnpur during August with the First Assistant, to make arrangements for the despatch of bollworm parasites to Egypt. Mr. A. Alfieri visited Pusa from July to September on behalf of the Khedivial Agricultural Society of Cairo in connection with bollworm parasites. Lala Bishambar Das, Assistant Professor of Biology, Government College, Lahore, worked in the Laboratory from October to December. Lala Madan Mohan Lal, Assistant Professor of Entomology, Agricultural College, Lyallpur, spent three weeks in the Laboratory during October. The Entomological Assistant of Baroda visited Pusa in April to discuss his programme of work for the ensuing year. Mr. N. N. Pillai, Weaving Expert to the Government of Bengal, visited the Silk House during April. Mr. Cook, Principal of the Weaving School, Benares, inspected the dyeing work carried out in the Silk House.

X.—PROGRAMME OF WORK FOR 1913-14.

As previously, investigations into crop pests and suggesting of remedial measures will be continued, and accounts of their life-histories, etc., will be published as material accumulates. The short courses in lac cultivation and Eri and Mulberry silk cultivation will be given as formerly, and also the training of students in general entomology. The cultivation of lac for experimental and demonstration purposes will be continued. The work with Mulberry silkworms will be carried on. Eri worms will be reared and help and advice on both Eri and Mulberry cultivation will be afforded as far as practicable. Experiments with European bees, especially from the point of view of queen raising, will be continued. It is hoped that it will be possible to test the honey-gathering qualities of the Indian bee, *Apis indica*, during the coming spring. Insecticides and apparatus, sent in for trial, will be tested and reported upon. The field experiments with wheat and sugarcane will be continued. If funds are available more coloured plates will be published and the work of preparing lantern slides will be continued. Where desired, help will be given to the Provincial Assistants in their work, and in case of serious outbreaks of pests special assistance will be given. The special investigations with insects attacking stored wheat will be continued as also the experimental work with cotton bollworm.

XI.—PUBLICATIONS.

1. Tetriginæ (Acridinæ) in the Agricultural Research Institute, Pusa, with descriptions of new species. Dr. M. L. Hancock Gough. *Mem. Dept. of Agri., India*, Ent. Ser., Vol. IV, No. 2.
2. The Big Brown Cricket (*Brachytrypes Achatinus*, Stoll). C. C. Ghosh. *Mem. Dept. of Agri., India*, Ent. Ser., Vol. IV, No. 3.
3. Life-histories of Indian Insects.—IV (Hymenoptera). G. R. Dutt. *Mem. Dept. of Agri., India*, Ent. Ser., Vol. IV, No. 4.

4. Inquiry into the Insecticidal action of some Mineral and other Compounds on Caterpillars. H. M. Lefroy and R. S. Finlow. *Mem. Dept. of Agri. in India*, Ent. Ser., Vol. IV, No. 5.
5. Cultivation of Lac in the Plains of India. C. S. Misra. *Bull.* 28, *Agri. Res. Inst., Pusa*. (Second Edition in the press.)
6. Directions for the Cultivation of Eri Silk. *Bull.* 29, *Agri. Res. Inst., Pusa*. (Second Edition in the press.)
7. Litchi Leaf Curl. C. S. Misra. *Agri. Journ. of India*, Vol. VII, Pt. III, July, 1912.
8. The "Psylla" disease of Indigo in Bihar. H. M. Lefroy. *Agri. Journ. of India*, Vol. VIII, Pt. I, January, 1913.
9. The Red Spider on Jute. C. S. Misra. *Agri. Journ. of India*, Vol. VIII, Pt. IV (in the press).
10. Life-history of *Helicomitax dicax*. C. C. Ghosh. *Bom. Nat. Hist. Soc. Journal* (in the press).
11. Instructions for rearing Univoltine Mulberry Silkworms. M. N. De. *Bull.* 39, *Agri. Res. Inst., Pusa* (in the press).
12. Life-histories of Indian Insects.—Lepidoptera. C. C. Ghosh. *Mem. Dept. of Agri. in India*, Ent. Ser., Vol. V, No. 1 (in the press).

Publications in preparation:—

Memoir on Indigo Psylla.

Memoir on Orthoptera.

Memoir on Coleoptera.

Memoir on Heterocera.

Memoir on Hemiptera.

Memoir on Insects Injurious to Indian Agriculture, revised edition.

Memoir on Indian Economic Aleurodidae.

Bulletin on Fruit Pests.

Bulletin on Bees and Bee-keeping.

Vernacular translation of Bulletin No. 28 (revised edition) on the "Cultivation of Lac in the Plains of India."

REPORT OF THE IMPERIAL PATHOLOGICAL
ENTOMOLOGIST

(F. M. HOWLETT, B.A., F.E.S.)

I.—ADMINISTRATION.

I was in charge of the section throughout the year, but spent two months in September and October on privilege leave.

Of the work which is summarised in this report, I owe not a little to the stimulus of frequent correspondence, conversation and collaboration with many medical officers more or less directly engaged in entomological work. The probable severance of these relations in the near future is to me a source of regret.

II.—VETERINARY WORK.

In January I circularized all Provincial Directors, enquiring whether there was any veterinary research in progress which I could assist from the entomological side, or any special direction in which they would suggest that entomological investigation should be prosecuted. The majority replied that the services of an entomologist were not at present required; Madras, Burma and the Central Provinces referred to the collection of possible Surra-carriers, and the Central Provinces also mentioned the parasites of sheep.

Major Holmes proposes an investigation of the insect carriers of Surra at Kathgodam. An assistant has been given special training in order that he may assist by carrying on the rearing of *Tabanidæ* and other blood-sucking *Diptera* which will be required in this enquiry.

A large collection of Ticks, mostly from Veterinary Officers of the different provinces, has been consigned to Professor Nuttall at Cambridge, there to be examined and identified in connection with Professor Nuttall's monographs on the subject which are now appearing.

An attempt was made to repeat the observations of Hindle and Merriman on the smell-reactions of Ticks (*Argas* and *Hyalomma*), but I was unable to obtain the same results. The matter is one of considerable interest, and I propose to return to it.

III.—AGRICULTURAL WORK.

This was practically confined to the subject of fruit-flies of the genus *Dacus*.

A poison-spray method, which depends for its efficacy on the habit of the peach-fly (*D. Zonatus*) of sucking tentatively at any little drop of moisture on a leaf, was tried with excellent results. The proportion of affected peaches in the sprayed plots was approximately 2 per cent. over the whole period of picking, in place of the usual 45–60 per cent. The cost of the method is very small compared with the value of the crop, and should this year's results be confirmed by another season's work, they will have a very considerable commercial importance.

In the course of experiments on the chemotactic reactions of male fruit-flies I have found that these insects are strongly attracted by certain compounds allied to Eugenol ($C_{10}H_{12}O_2$). These compounds thus constitute a means of detecting the presence of the flies in a given locality with a degree of certainty quite unattainable by any ordinary method of observation.

Using this chemical test in the course of a tour in March through Bihar, the United Provinces, the Punjab, and the North-West Frontier Province, I found that the North-Western limit of the distribution of peach-fly practically corresponded with the South-Eastern limit of successful peach-growing.

Mr. and Mrs. Howard have shown that under the climatic conditions which obtain at Pusa it is possible to grow first-rate peaches. That peaches are not largely or profitably grown in the Southern and Eastern portions of the Gangetic Plain and in various districts in Southern

India is, I believe, due very largely or entirely to the abundance of peach-fly, 50 per cent. or more of the crop being almost invariably maggotty. It thus appears probable that the application of the poison-spray method may result in opening up, for the profitable cultivation of sound peaches, large areas where such cultivation is at present impossible owing to the ravages of the fly.

IV.—MEDICAL WORK.

The two genera concerning which information was chiefly desired by the Medical Department were *Stegomyia* and *Phlebotomus*.

A course of instruction in the identification, breeding and general observation of *Stegomyia* was given in July to Medical Officers engaged in the "Stegomyia survey." The life-histories of all the species occurring at Pusa have been worked out in their main features. Careful observations have been carried on throughout the whole year on the seasonal prevalence of the different species, and it has been established as a practical certainty that all species are normally in the habit of tiding over periods of drought as dry eggs, even though these periods may be of six months or even longer duration.

Anti-*Stegomyia* operations have been carried out at Pusa, with a very marked result on the numbers of these mosquitos, which in past years have been invariably very troublesome in the rains. This year it is rare to find them in the bungalows.

The methods adopted have been the filling up with earth or plaster of Paris of all known or probable breeding-places, particularly holes in trees and cut bamboos, and the simultaneous provision of "trap-breeding-places" in the form of bamboo-joints filled with water which are emptied out as soon as larvæ make their appearance in them. I regard this trapping method as a distinct advance on mere indiscriminate destruction, and with modifications it might be found a valuable aid in anti-malarial operations.

Coloured plates were prepared illustrating all stages of the life-history of the different species of *Stegomyia* and allied genera occurring at Pusa, and a set of maps was also constructed, largely from information received from Medical Officers on the *Stegomyia* survey, showing the known distribution of the different species in India. These plates and maps, together with specimens of the mosquitos in different stages and other exhibits, were sent at the request of the Medical Department to the International Exhibition at Ghent to form a part of the Indian exhibit in the section of Tropical Medicine and Hygiene. A typical collection of mosquitos and other human parasites was also sent to Dr. Marzinowsky of Moscow.

A large number of observations have been made as to the action of different chemical substances on the eggs and larvæ of mosquitos (*Stegomyia scutellaris*, *Myzomyia rossii*, and *Culex fatigans* and *microannulatus*).

It has been found that ordinary powdered Calomel (mercurous chloride) has many of the properties of the ideal larvicide, and this substance certainly merits a more extended trial to ascertain its cost and efficacy under field-conditions. The action is comparatively slow, but sure and apparently lasting, while the amount which it is necessary to use is so minute that treated water is in no way harmful or uncomfortable for ordinary use by men or cattle.

Observations have also been made on the method of feeding and the nature of the food and digestion of mosquito-larvæ, and on the respiration and oxygen-consumption of larvæ and pupæ. Methods of colouring mosquitos for identification in flight-determination have been tried with success as far as permanence and ease of identification are concerned, both carmine powder and gentian-violet giving good results.

The breeding of West Indian "Millions," obtained in the first instance from the Officiating Sanitary Commissioner of the United Provinces, though quite successful under "semi-domestic" conditions, has been a failure when

the fish have been transferred to large *pucca* tanks. This seems to be owing to the attacks of the larvæ of large Dytiscid water-beetles which are common here, and which destroy the young fry and even the adult fish. It is probable that the native *Haplochilus* is, under Indian conditions, at least as effective a larva-destroyer.

With regard to sand-flies (*Phlebotomus*) the life-histories of *Phlebotomus papatasi*, *P. argentipes*, and *P. minutus* have been worked at.

Attention was mainly directed to *P. minutus*, which is the commonest species at Pusa, and a large amount of time has been spent in the difficult task of discovering natural breeding places. The preliminary results of this enquiry were presented in a paper read at the Malaria Conference at Madras.

By combining these results with those obtained in a series of experiments on the predilections of the larva and of the fly for various foods and for different hosts, it appeared probable that there was some connection between the fly and the wall-lizards or Geckos commonly found on tree-trunks and the walls of bungalows. Subsequent observations have shown that this supposition is correct, and that there is undoubtedly a close connection at several points between these reptiles and *P. minutus*. In a paper contributed to the "Indian Journal of Medical Research" I have put forward the view that the "real" hosts of this sand-fly are lizards, and that the connection with man may be of a secondary nature.

Attention has lately been directed to the hosts attacked by *P. argentipes*, as little is known of the biting habits of this species, but no very definite results have yet been obtained. *P. papatasi* will be most easily investigated in the Punjab or North-West Frontier Province, where it is far commoner than at Pusa. The results obtained through the excellent work of Professor Newstead and Captain Marett in Malta will probably be found applicable to India, and can be taken as a basis for further investigation of the habits of this species.

At the end of the rains I spent some time in Poona in company with Captain Morison, I.M.S., and inspected the breeding-grounds of Muscid flies which were suspected of a connection with a form of enteritis prevalent at Poona. Experiments on marked flies were carried out to ascertain how far the city trenches were responsible for the very great abundance of flies in the city and cantonments. An assistant was deputed to remain at Poona and assist Captain Morison in the investigation of breeding-places and the other entomological work necessary. An assistant was similarly deputed to assist Major Greig, I.M.S., in his investigation of typhoid fever at Puri, and the part played by flies in its transmission. In collaboration with the Medical Officer at Pusa observations are being made on the flies responsible for the cases of myiasis which are somewhat common in the district.

One assistant attended the malaria class, under Captain Hodgson, I.M.S., at Delhi. A large number of mosquitos and other insects, sent in mainly by Medical Officers, have been identified. I gave a series of lectures with practical instruction on methods of drawing and illustrating.

In November I had the pleasure of attending the Malaria Conference at Madras and read three papers :—

“ The yellow-fever mosquito.”

“ The breeding-places of *Phlebotomus*.”

“ Insect psychology and its bearing on methods of control.”

Two papers have been contributed to the first issue of the “ Indian Journal of Medical Research ” :—

“ The natural host of *Phlebotomus minutus*.”

“ Insect life-histories and parasitism.”

V.—PROGRAMME FOR 1913-14.

Fruit-flies and Parasitic Insects.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST

(C. M. HUTCHINSON, B.A.)

I.—ADMINISTRATION AND TOURS.

I held charge of the section throughout the year excepting three weeks' privilege leave in September, when Mr. Joshi was in charge.

The staff was considerably strengthened by the sanction of the following additional appointments :—

Supernumerary.—Mr. J. H. Walton, B.A., B.Sc., was appointed as Supernumerary Agricultural Bacteriologist, and joined this section on 25th October 1912.

Assistants.—Two posts of Assistants on Rs. 75–125 each were sanctioned: one was given to Mr. C. S. Ram Aiyer, B.A., an Assistant in this section; and the other to Mr. N. C. Bose, an Assistant in the Chemical Section. Mr. Bose was appointed in this section on 18th April 1913. Mr. N. Dayal Singh was appointed in this section, as Fieldman, on 1st May 1913.

Mr. Vishwanadham, Second Assistant, was on privilege leave from 25th March 1913 to 27th April 1913. Mr. Ram Aiyer, Third Assistant, was on privilege leave from 8th July 1912 to 20th August 1912.

The outside laboratory building was completed and work commenced in it in June 1913; Mr. Vishwanadham, Second Assistant, has been put in charge of this building. It is primarily intended for pot-cultures and work on ammonification and nitrification in soil media; an important feature is the locally made pressure sterilizer capable of sterilizing six large or twelve smaller sized culture pots simultaneously under 40 lbs. steam; this will also be available for use by the Mycological Section.

The compound attached to this building will be used for experimental plots; pits for growing rice under varying

conditions of water supply have been made and are now in use; green manure (sann) has also been grown for experimental purposes.

Tours.—*To Muktesar* to discuss various matters connected with bacteriological technique in India with the Imperial Bacteriologist.

To Muzafferpore to attend meeting of Bihar Planters' Association.

To Nagpur to examine soil conditions and obtain samples from sewage treated area.

To Bettiah to investigate potato disease.

To Sirseah to consult Mr. Bergtheil on the subject of indigo disease.

II.—SOIL BACTERIOLOGY.

Nitrogen supply in the soil as affected by intervention of bacteria has been the principal subject of enquiry; in the previous year attention was confined to the conditions under which organic nitrogen of manures and residues is converted into ammonia and nitrates; this line of enquiry affords sufficient work to occupy the whole time of any establishment for many years, but it has been considered advisable to add to it an investigation of the natural conditions under which nitrogen is taken from the air and added to the soil in this country. This if carried out thoroughly would also involve a very large amount of work, but it seems advisable in dealing with such a question as soil bacteriology in this country, where no work on this subject has been carried out before, to make preliminary enquiries, however superficial, on similar important questions, in order to gain some idea of the most useful direction in which to pursue the subject more fully. This is the more necessary on account of the still early stage of development of soil bacteriology as a science, and the fact that many fundamental theories connecting bacterial action with soil fertility have not yet been accepted as axiomatic. It is perhaps unnecessary to emphasize the importance of the question of nitrogen fixation, but it may be pointed out

that there is very good reason for supposing that upon this depends the ultimate prosperity of a country, the mineral wealth of which not being commensurate with its agricultural area and population debars it from the purchase of adequate supplies of nitrogen from external sources. At the present time the need of nitrogen in India is becoming increasingly greater owing to the introduction of intensive cultivation, although up till now the soils of this country as a whole have been preserved from undue depletion by the generally superficial and extensive nature of the cultivation employed, which has prevented large crops from being taken off the land, after the reduction of the original virgin soil to the normal level of fertility by the growth of crops. At the same time deportation of nitrogen in the form of produce exported from areas in which it was grown has not been excessive, and in the case of rice much fertilization of the soil takes place by deposition of organic matter carried down from jungle tracts by the irrigation water. Nowadays, however, this state of affairs is being rapidly altered owing to the expansion of Indian trade, which not only transports foodstuffs from agricultural districts to feed the increasingly large populations of cities, but carries enormous quantities of produce out of the country, including not only cereals, oilseeds and fibres, but bones and hides which represent nitrogen collected from very extensive areas of land. If now, in addition to this constant drain upon the nitrogen resources of the soil, intensive cultivation is introduced, meaning the more rapid conversion of non-available plant food, especially nitrogen, into the available condition, depletion will certainly follow, differing in intensity from such a result in temperate climate as the average soil temperature in India differs from that in Europe, but in an even higher degree. This difference due to temperature has been observed and measured in this laboratory as affecting ammonification, nitrification, and the formation of carbon dioxide by oxidation of the organic matter of the soil, and is not one of a slightly higher degree, but may easily attain to an increase

in rate of one hundred per cent. or more; the concurrent loss of nitrogen is not to be measured, therefore, only by the increased crops taken off the land, but by losses in the form of ammonia and of nitrate washed out during the rains from fallows in well drained areas.

A further point must not be overlooked; on the credit side of the nitrogen account must be placed the addition of this element to the soil through the intervention not only of leguminous plants, but of nitrogen-fixing members of the soil flora such as *Azotobacter* and *Clostridium*; the physiological activity of these organisms, however, is strictly limited by soil conditions, and especially in the case of the former by the supply of carbohydrate food, so that should intensive cultivation, carried out without regard to this aspect of the case, lower the supply of organic matter beyond the optimum point for nitrogen fixation by the above-mentioned organisms, this source of nitrogen would be cut off, and the discrepancy already existing between the two sides of the account would be further increased, probably in geometric proportion.

During the past year *Azotobacter* has been found in all Indian soils examined, including those of such widely differing character as may be found in Sind, Nagpur, and Assam; pure cultures of *A. Chroococcum* from such various sources exhibited nitrogen-fixing power very similar to that recorded from European strains, its physiological activity depending upon appropriate supplies of water, air, lime and especially of carbohydrate food. It is intended to carry out a general survey of Indian soils to get some idea of the distribution of this and similar organisms and the conditions under which they may most readily carry on nitrogen fixation in these soils.

The green manuring experiment begun in collaboration with the Imperial Agriculturist during the previous year was carried on, and will continue in 1913-14. The successful use of a green manure crop was found to depend almost entirely upon the incidence of the rainfall succeeding the burying of the crop, partly owing to the loss of

soil moisture by transpiration during the growth of the green manure, and partly to the necessity for providing a considerable percentage of soil water to ensure the proper decomposition of the buried material. Further experiments during the current season include a special method of dealing with a green manure crop designed to avoid the loss due to want of sufficient soil moisture to ensure complete decomposition after burying; this method consists in hastening the initial stages of decomposition by steeping the cut crop in water and then fermenting it in heaps, under which conditions the less readily decomposed cell walls and lignified tissues are rapidly attacked by bacteria favoured by semi-anærobic conditions; the fermented material is then used in the same way as farm yard manure. The advantages of this method, in addition to the principal one of eliminating the uncertainty of the rainfall as a factor in decomposing the buried green material, include the possibility of applying the fermented manure at the best rate per acre and at the best time for producing its optimum manurial effects; at the same time it is not necessary to grow the green manure crop on the land which is to carry the "rabi" crop intended to benefit by its manurial effect; in some cases this might be of great advantage with regard to the depletion of the soil moisture consequent on transpiration during the period of growth of the green manure crop. This method of dealing with a green manure crop closely resembles the practice in indigo-growing districts of manuring tobacco and other soils with the refuse ("Seet") from the indigo factory, which is obtained by steeping the cut indigo plant in water for some 24 hours and subsequently allowing the sodden plants to lie in heaps in which fermentation goes on; the rotted material thus produced is generally applied to tobacco lands, the rented value of which depends almost entirely upon the local availability of the indigo "Seet."

The field experiments with green manure in 1912-13 included the growth of a "rabi" crop (wheat) on the experimental area. In no case was there any increase in

yield from the green manured plots, and in many there was a decided falling off. There can be no doubt that this result was due to the failure of the generally expected rainfall in September and October (locally known as the "Hathia") as it was found on examination that the buried stems of the green manure had failed to undergo complete decomposition.

Laboratory experiments showed that the nitrate formed from the buried plant tissues increased in amount up to the end of eight weeks from the time of turning into the soil, provided the water supply was kept up to at least 16 per cent. of the soil weight, but after this period a steady diminution took place, so that after twelve weeks a smaller quantity of nitrate than that present at the end of the eighth week was invariably found. The cause of this loss was not discovered, although it may be conjectured that it was due to the demands of the soil organisms for nitrogen, but its invariable occurrence is interesting as helping to explain the already well-known fact in field practice that too long an interval between the burial of a green manure and the sowing of the succeeding "rabi" crop is prejudicial to the latter so far as any improvement which may be expected from the use of the former is concerned.

The results of the first year's experiments on green manuring will be published in the form of a Bulletin.

Further work on the occurrence of bacterio-toxins in soil, their relation to infertility, and the action of tillage, drainage, and manurial application in neutralizing them, was carried out.

Biological analyses of various soils were made and further modifications of the method introduced; this subject is still in a very early stage of development, especially so far as interpretation of results is concerned, but it is hoped that further experience and modification of the method will lead to its successful application to the solution of various soil problems. At present it is possible to determine the optimum moisture content of a soil for

certain biological processes necessary for fertility, to ascertain approximately the organic manures most suitable for application, with the important reservation that the sample experimented on may not be truly representative of the area to be treated; this source of error is greatly minimised by the use of large samples and the introduction of the method of using soil media in place of inoculating liquid media with small samples of soil; thus in the old method one gram of soil was generally used as inoculum and the biologic activity of the soil as a whole was judged therefrom, whereas in the method now used, estimations of nitrifying and ammonifying capacity and efficiency, and general biologic activity, are made with samples varying from 400 grams to 1,200 grams.

III.—SPECIAL ENQUIRIES.

(1) *Sewage Farms*.—At the request of the Principal of the Agricultural College, Nagpur, a series of investigations was commenced with a view to determining the effects of the application of sewage upon the biological condition of the soils of the College Farm. I visited Nagpur and inspected the farm soils and the sewage installation, and discussed with Mr. Allan and Mr. Plymen, the general arrangement of the experimental plots to be put under treatment. An arrangement was made for sending periodic samples to Pusa for examination, and at the same time Mr. Plymen agreed to carry out chemical analyses to determine nitrate at Nagpur.

(2) *Rice*.—An experiment was arranged to determine the effect of soil toxins upon the growth of the rice plant; this was in connection with the work of the Imperial Mycologist upon the "Ufra" disease of this crop, as it was considered possible that the incidence of this disease might depend upon adverse soil conditions. Rice was grown in pots in soil to which large quantities of mustard cake were added, it having been found that the initial stages of decomposition of this manure give rise to bodies which are toxic to plants. The pots were arranged so that

in one set lack of drainage should allow of accumulation of the toxins produced, whilst in the other continuous percolation removed them in solution. The results completely verified expectation, as not only was growth seriously interfered with in the undrained pots, but the root formation in the drained set showed that the toxins carried down by the percolating water had inhibited root growth in the lower soil, whereas in the undrained series more root development took place below than above. No symptoms of "Ufra" appeared, but Dr. Butler has now demonstrated conclusively the connection between this disease and the presence of nematodes in the plants, nor does it appear that soil conditions adverse to healthy growth render the plants more liable to attack.

(3) *Tobacco*.—The work on Tobacco Wilt in the Rangpur District was concluded and a Memoir on the subject published in the Bacteriological Series.

(4) *Indigo*.—Plants of Java variety were grown and kept under observation for symptoms of wilt in order to determine a possible bacteriological origin of this disease; this work will go on through current season.

(5) *Potato Rot*.—An extensive series of investigations was carried out, mainly by Mr. N. V. Joshi, First Assistant, as to the cause responsible for the very common rotting of tubers in store. The Economic Botanist to the Government of Bihar and Orissa, at whose instance this work was undertaken, provided samples from various godowns in Bihar, and others were received from Poona. Two rotting bacteria were found to be present invariably, and these appear to be normal in Indian soils. It was found that rotting could take place in presence of these bacteria either if the dry tubers suffered mechanical injury or if the uninjured tuber were kept under conditions in which its surface could remain moist for a few hours. Thus tubers stored in sand to keep out potato moth can be attacked if the rotting organisms are present, either through bruising due to careless handling or by reason of the sand not being perfectly dry, or by contact between a rotting

potato exuding moisture and a sound one; this last possibility necessitates frequent examination of stored tubers and picking out of rotten ones. Various antiseptics were tried on a small scale, of which copper sulphate proved the best; this will be tested along with other preventive measures in the ensuing season.

IV. PROGRAMME OF WORK FOR 1913-14.

A.—Biological aspects of soil under —

- (1) Treatment with green manures.
- (2) Rice cultivation.
- (3) Sewage.
- (4) Varying methods of tillage.

B.—Disease of indigo and solanaceous plants.

C.—General work on biology of soils and biological analysis.

D.—Training of students.

V.—PUBLICATIONS.

1. Rangpur Tobacco Wilt. C. M. Hutchinson. *Mem. Dept. of Agri. in India*, Bact. Ser., Vol. I, No. 2.
2. Drainage in Rice Soils. C. M. Hutchinson. *Agri. Journ. of India*, Vol. VIII, No. 1, January, 1913.

REPORT OF THE IMPERIAL COTTON SPECIALIST

(G. A. GAMMIE, F.L.S.)

I.—CHARGE AND TOURS.

I held charge of the appointment of Imperial Cotton Specialist throughout the year.

During the month of October 1912 I visited the North-West Frontier Province to discuss present and future operations in cotton cultivation with the Revenue Commissioner and the Superintendent of Farms. In November I attended the annual meeting of the District Agricultural Associations at Akola, where I met the Director and Deputy Director of Agriculture of the Central Provinces and then went on to Nagpur to confer with the Economic Botanist regarding his work on the improvement of his provincial cottons. In December I accompanied the Director and Deputy Director of Agriculture, Bombay, on a tour to all the experimental stations in Guzerat where we had ample opportunities of discussing matters on the ground greatly to our mutual benefit and understanding. In March I was on tour with the Director and Assistant Deputy Director of Agriculture in the Southern Mahratta Country and here again we had an opportunity of settling many points of interest in the fields. In April and May I was on tour in Guzerat with the Deputy Director of Agriculture. The intervening periods throughout the year were spent at head-quarters, supervising my own experimental station, arranging for the distribution of seeds required by many correspondents and also for the valuation of samples of cottons received from all parts of India.

II.—COTTON IN THE PROVINCES.

(a) *North-West Frontier Province.*—The following are my notes drawn up after a visit to this province. The

local variety of cotton is so productive and in every way so suitable to this province that I would not suggest replacing it by any other variety—either Indian or foreign. It is a mixture of varieties of the *neglectum* type and we agreed that the plants with narrow lobed leaves and pendulous lint should be selected and of these the best plant should be taken as the parent of the future stock. The red flowered cottons (*Multan*) may prove to be remunerative if they ripen in time, but, as this is doubtful, I should emphasize the necessity of the Department confining its trials to one type of plant. The value of this advice will be fully appreciated when seed in sufficient quantities is available for distribution. Then there is only one sort to deal with and mistakes and mixtures cannot possibly creep into the work.

The American cottons, as plants, are well grown but will not ripen their bolls. So far as we can at present judge, there are no great possibilities for exotic cottons in this tract, but there need be no discouragement on this score as the local product is quite satisfactory.

(b) *Punjab*.—Samples of 22 varieties were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation and I append a copy of their report. These cottons have been grown on the Lyallpur Farm for several years and it is now time that some action should be taken in the selection and multiplication of the most promising for distribution to cultivators.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 22 samples of cotton grown on Lyallpur Farm, on 15th May 1913.

Serial No.	Sample No.	REMARKS.
1	7F	This cotton equals Middling American in colour, staple and strength, only it is slightly coarse to the feel. It can spin 40 ^s . We value it at Rs. 350 per candy, say the price of Middling American cotton laid down in Bombay.
2	70F	Slightly shorter than No. 1 in length of fibre; in all other respects it is equal to the above. It can spin 30 ^s - 32 ^s . Value Rs. 335.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 22 samples of cotton grown on Lyallpur Farm, on 15th May 1913—contd.

Serial No.	Sample No.	REMARKS.
3	72F	This is really an excellent cotton of a quality superior to Middling American. It can easily spin 50 ^s and our valuation is Rs. 400 per candy.
4	110F	This cotton is barely superior in spinning quality to Fine Surats. The fibre is weaker than No. 2 and cannot spin over 22 ^s . Value Rs. 350.
5	111F	It resembles No. 1 in all respects, only the fibre is slightly stronger. It can easily spin 40 ^s . For strength of staple we value it Rs. 10 over the price of No. 1, say Rs. 360.
6	126F	This cotton resembles Fine Surats in its spinning quality. It is stronger in fibre than No. 4 and can spin 24 ^s . Value Rs. 325.
7	161F	It is slightly superior to No. 1 and can easily spin 40 ^s . We value it at Rs. 360 per candy.
8	168F	It is the exact counterpart of No. 4. Will spin 22 ^s . Value Rs. 320 per candy.
9	179F	This cotton lacks in body and has a different appearance than any of the above. It has, however, a soft feel though the fibre is of variable strength. On the whole it can spin 24 ^s and may be valued at Rs. 325 per candy.
10	199F	Equals No. 2 in all respects. Can spin 30 ^s —32 ^s . Value Rs. 335.
11	112F	Same as above. Will spin 30 ^s —32 ^s . Value Rs. 335.
12	211F	Equal to No. 6 in all respects. Will spin 24 ^s . Value Rs. 325.
13	226F	It is equal to ordinary Fine Broach, only it is superior in colour. It will spin up to 20 ^s . Value Rs. 295—Rs. 3 being added to the price of Broach for colour.
14	232F	Same as above. Will spin up to 20 ^s . Value Rs. 295.
15	233F	Equal to No. 2. Will spin 30 ^s —32 ^s . Value Rs. 335.
16	275F	Equal to No. 1. Can spin 40 ^s . Value Rs. 350.
17	280F	This is an excellent cotton equal to No. 3. Will spin 50 ^s . Value Rs. 410. We have added Rs. 10 to the value as we find that it is all round slightly better than No. 3.
18	281F	Equal to No. 1. Will spin 40 ^s . Value Rs. 350.
19	282F	Equal to No. 3. It is an excellent cotton. Will spin 50 ^s . Value Rs. 400.
20	266F	Equal to Surats in spinning quality. It is like No. 6. Will spin 24 ^s . Value Rs. 325.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 22 samples of cotton grown on Lyallpur Farm, on 15th May 1913—concl'd.

Serial No.	Sample No.	REMARKS.
21	..	<i>Deshi cotton, zamindari sample</i> , has all the characteristics of Sind Punjab cotton. It can spin up to 10 ⁺ and we value it at same price as Fine Sind Punjab Ginned, namely, Rs. 245.
22	..	<i>American cotton, zamindari sample</i> , shows good deal of variation in the length as well as the strength of the fibre. It seems that proper attention was not paid to this cotton on the zamindari land, hence the deterioration. We pull out a sample from a handful of this sample which can easily spin 24 ⁺ while another handful from the same sample gives a staple which can hardly spin 20 ⁺ . We therefore conclude that this "Mixed Staple" will not spin beyond 20 ⁺ and we value it at Rs. 315, say, Rs. 5 lower than our quotation of Surats.

Basis of prices on 13th May 1913 :—

	Rs.	
Middling American	350	per candy of 784 lbs.
Good Tinnevelly	330	" " " "
Fine Surat	320	" " " "
" Broach	292	" " " "

In forwarding this report I added the following remarks :—

" These cottons have now been successfully grown on the Botanical Experimental Farm for the past five years so that their suitability for your conditions has been abundantly established. From a practical point of view the distribution of the seed and subsequent supervision of the product of 20 selections is not possible and it would be as well to determine how few of these should be ultimately maintained.

Variety.	REMARKS.
7F	Last year was compared with and valued equal to the best Surat cotton, or Rs. 45 per candy less than Good Middling American. This year it is valued as equal to Middling American laid down in Bombay at Rs. 350 compared on the same day with Good Tinnevelly, Rs. 330 ; Fine Surat, Rs. 320 ; and Fine Broach, Rs. 292.

Variety.	REMARKS.
70F	Last year this was compared with the best Broach and valued at Rs. 5 more ; this year it is reported to be worth Rs. 335 or Rs. 15 less than 7F.
72F	Last year was reported to have a characteristic and style of Best Surat, being slightly better than 7F in length of fibre, and it was valued at Rs. 5 higher than 7F, i.e., Rs. 325 per candy. This year it is said to be an excellent cotton of a quality superior to Middling American and its valuation is Rs. 400 per candy.
110F	Last year this cotton was said to resemble the superior grade cottons grown in the Central Provinces such as Warora and Hinganghat on account of its being slightly dull in colour and was valued at Rs. 5 lower than Warora. This year the cotton is found to be hardly superior in spinning quality to Fine Surats and is valued at Rs. 320 (Rs. 350 in the report being an error).
111F	Last year was found to be equal to 7F. This year the same conclusions have been arrived at, but on account of the fibre being slightly stronger it is valued at Rs. 10 more.
112F	Last year was the same as No. 111F, but a shade shorter in the length of fibre, therefore valued at Rs. 5 less ; this year it equals No. 70F.
126F	Last year it was said to be midway between the best Broach and Surat and valued at Rs. 10 more than Fine Broach. This year reported to resemble Fine Surats in spinning quality and valued at Rs. 325.
161F	Last year was considered to be the best of its kind grown in Indian soil and acclimatized in India. Valued at Rs. 385 against Rs. 365 for Good Middling American. This year it has been reported to be slightly superior to 7F and valued at Rs. 360, Middling American being Rs. 350.
168F	Last year and this year also reported to be hardly superior to Fine Surats.
179F	Last year reported to be equal to Fully Good Middling American. This year found to be lacking in body and with fibre of variable strength. Something has evidently happened to this number and it should be discarded.
180F	Last year valued at Best Broach style of cotton. This year it is said to be equal to 70F. This could be thrown out.
211F	Equals No. 126F and need not be kept up.
226F	Last year reported to be of the style of inferior cottons of the Central Province. This year is said to be equal to Ordinary Fine Broach.
232F	Last year and this year also reported as equal to 226F.
233F	Last year reported to be equal to 226F and this year equal to No. 70F. There is some discrepancy which should be inquired into.
275F	Last year said to be Broach style of cotton ; this year is said to equal No. 7F.
280F	This year said to be equal to 72F or perhaps Rs. 10 better.
281F	Reported to be equal to No. 7F.
282F	Equal to No. 72F.
266F	Equal to No. 126F.

“ *Basis of valuation on 10th May 1912 :—*

	Per candy of 784 lbs.
American Good Middling	7½d. c.i.f.
	Rs.
” ” ”	365 Net.
Fine Navasari	340
” Surat	320 ”
” Broach	285
” Warora-Hinganghat (Central Provinces)	290 ”
” Wardha	285 ”
” Yeotmal (Berars)	280 ”
Good Tinnevelly	320

“ *Basis of valuation on 13th May 1913 :—*

	Per candy of 784 lbs.
Middling American	350
Good Tinnevelly	330
Fine Surat	320
” Broach	292

“ Zamindari sample of *Deshi* cotton has all the characteristics of Sind Punjab cotton.

“ American zamindari sample is reported to show good deal of variation in the length as well as the strength of fibre. It is valued at Rs. 5 lower than Surats.

“ An analysis of the report of your samples brings to light the fact that Nos. 72F, 161F, 280F and 282F in point of quality are by far the most desirable and it is quite probable that no harm would be done if these are mixed and treated under one number. You will then have a cotton which would meet the requirements of manufacturers for a high grade class of cotton grown in India. The only important doubt which remains in regard to these is whether their production is on a par with the quality; but this is a point which you have no doubt worked out. If the production is really satisfactory, I would strongly recommend you to do as I have already suggested; mix these numbers already given, test them on a large field scale—and if the result is still satisfactory the seed could be produced on seed farms for distribution in large quantities to selected cultivators. If you wish to keep them up, a number of the inferior types in your list could also be

amalgamated; for instance, from the point of quality alone there is no particular reason for keeping separate Nos. 126, 168, 211, 266.

" You should bear in mind that, unless you distribute the seed of only one variety or type into each tract or district, you will soon receive complaints of mixed cotton from the traders and the cultivators will suffer."

(c) *United Provinces of Agra and Oudh*.—The following valuations of Messrs. Tata, Sons & Co., on samples from Mr. Burt, are interesting as they show the strong possibilities of ultimate success in the cultivation of American cottons in the United Provinces. Until we apply the crucial tests of acreage outturn, percentage of cotton to seed, and other factors to these varieties it is obviously unsafe to say whether all or any of them are really profitable to grow, and it is to be hoped that the United Provinces Department of Agriculture will soon furnish us with the required information. The experiments in progress on the indigenous varieties are identical with those we have carried out to a definite conclusion in Berar and Khandesh.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the four samples of cotton from Cawnpore, on 16th July 1913.

Serial No.	REMARKS.
1	<i>Dharwar American</i> .—Dharwar American seed sown in Cawnpore soil shows marked improvement in staple, though the colour has deteriorated. We value it at Rs. 290, say Rs. 25 more than the price of Dharwar simply for its staple.
2	<i>Cawnpore American acclimatized</i> .—The above remarks apply to this sample too, only the staple is slightly shorter than that of No. 1. Value Rs. 285, Rs. 20 above the price of ordinary Sawginned Dharwar.
3	<i>Boyd</i> .—This cotton is equal in all respects to Middling American. We value it at 6½d. per lb. laid down in Bombay, the equivalent in rupees being Rs. 350 per candy, Bombay terms.
4	<i>Black Rattle</i> .—This is a specially long stapled American cotton, equal to 1½" Bender American in staple and to Good Middling in class. We value it fully ¾d. higher than Middling. Taking Middling at 6½d. this cotton is fully worth 7½d. per lb., rupee equivalent being Rs. 400 per candy, Bombay terms.

Basis of value.—Fine Khandesh, Rs. 230; Good Sawginned Dharwar, Rs. 652; and Middling American, Rs. 350 per candy.

(d) *Central Provinces.*—I have reported so often and so fully on the excellent work done in this province that I have now little further to say. The outturn of the hardy indigenous varieties is so satisfactory and the product meets the demand of its market so well that there is no incentive to push the claims of longer stapled cottons, more specially as the conditions of soil and climate do not by any means favour these. An experimental farm for their cultivation may, however, be established in Western Chhattisgarh where conditions seem more favourable to exotic varieties.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 9 samples of cotton from the Akola Farm, on 8th January 1913.

Serial No.	Name of variety.	REMARKS.
1	Berar Jari .	Ordinary Akola type of cotton. It is slightly harsh in feel. Value Rs. 318.
2	Rosea No. 1 .	Slightly superior to No. 1 in staple. Value Rs. 322.
3	Cutchica No. 1 .	Equal to No. 1. Value Rs. 318.
4	Vera .	It is better than No. 2, both in feel and length of staple. Value Rs. 325.
5	Malvensis .	Midway between Nos. 2 and 4. Value Rs. 323.
6	Bani No. 3 .	It has all the characteristics of stapled Berars cotton. It is silky and has a long, strong, even fibre. Value Rs. 355.
7	Saugor Jari .	A short stapled Oomra equalling Dhamangaum cotton in style and colour, but the staple is shorter. With Dhamangaum at Rs. 330 we value this at Rs. 325.
8	Bhuri I .	A long stapled cotton equal to No. 6, but slightly weaker in fibre. Value Rs. 345.
9	Bhuri II .	Same as No. 8, but the fibre is more weak. Value Rs. 340.

N.B.—We have compared Nos. 8 and 9 with a sample of Cambodia cotton which we have purchased lately at Rs. 325, and we have based our valuation of these two samples on this comparison.

Basis.—F. Akola good at Rs. 320 per candy.

Some of the cotton varieties from the Northern Division of the Central Provinces, already alluded to in previous

reports, have again been reported on from samples sent by Mr. G. Evans, the Deputy Director.

The following are Messrs. Tata's valuations; 10th April 1913 :—

Serial No.	Name of variety.	REMARKS.
8	Saugor Jari (white flowered).	It is softer in feel than Khandesh, but inferior in staple. Value Rs. 268. (Basis Fine Khandesh, Rs. 272.)
9	Saugor Jari (yellow flowered).	Better in staple than No. 8, and we value it same as Fine Khandesh, viz., Rs. 272 per candy.
10	Chhapara	This sample may be classed as between Nos. 8 and 9. Value Rs. 270.
11 to 18	..	These 8 samples may be classed as Khandesh cotton. Nos. 11 and 12 are inferior in class and we value them at Rs. 265. Nos. 13, 15, 17 and 18 are worth Rs. 270 per candy. Nos. 14 and 16 show improvement in staple and we value them at Rs. 275 per candy. (Basis Fine Khandesh, Rs. 272.)

Nos. 8 and 9, Saugor *Jari*, white and yellow flowered respectively, again show the superiority of the staple from yellow flowered plants.

No. 10 is another local form discovered by Mr. Evans and its value lies midway between that of Nos. 8 and 9.

(e) *Madras*.—The following valuations of samples from the Nandyal and Hagari Experimental Stations show very graphically the rapid deterioration which takes place even in Indian cottons when their environment is altered. The necessity for a continuous importation of the seeds of such cottons is clearly demonstrated.

Valuations furnished by Messrs. Tata, Sons & Co., Bombay, on 21st September 1912.

Serial No.	Name of variety.	REMARKS.
1	Northern	Shows no improvement in Nandyal soil. It looks like Kumpta, but being picked from selected plants, the fibre is longer than that of Kumpta. With Kumpta at Rs. 290 we value this cotton at Rs. 310.

*Valuations furnished by Messrs. Tata, Sons & Co., Bombay, on 21st
September 1912—contd.*

Serial No.	Name of variety.	REMARKS.
2 to 9	Northern	These are from the general crops and are very much alike except Nos. 2 and 6, which show a slight falling off in fibre. All are inferior to No. 1 in staple. Value Rs. 300.
10	Cambodia	Grown at Cumbum, the cotton has much deteriorated both in colour and staple. The fibre is variable. We compare it with Westerns, and Good Westerns at Rs. 265. We value the sample at Rs. 260.
11	Do.	Grown at Samalkot, it resembles Kumpta and find it equal to No. 1, only slightly inferior in colour. Value Rs. 305.
12 to 18	Selected	They equal the best class of Westerns. No. 12 has a slightly reddish tint, but is better in staple. Nos. 17 and 18 are slightly inferior in staple. With Westerns at Rs. 265, we value No. 12 at Rs. 275, Nos. 13 to 16 at Rs. 270, and Nos. 17 and 18 at Rs. 265.
19	Broach	Grown on Bellary soil, it has deteriorated and has adapted itself to the characteristic of the soil and has changed into Westerns. We value it at Rs. 270, say Rs. 5 better than ordinary Westerns.
20 and 21	Lalio and Kanvi	Grown on Bellary soil, both have deteriorated and have taken the appearance of Westerns. We value them at the price of Westerns, say Rs. 265.
22	Kumpta	The Bellary soil destroys the originality of an exotic and forces it to adapt itself to the soil and condition of the district. Kumpta, too, looks like Westerns, but the length of the Kumpta staple is maintained, hence we value it Rs. 10 better than Westerns, say Rs. 275.
23	Black-seed. Western.	The best indigenous cotton both in colour and length of fibre. Value Rs. 275.
24	Surat Broach	Compared with No. 19 it has not deteriorated on Bellary soil as the seed was recently imported. Value Rs. 280.
25 and 26	Surat Kanvi and Lalio.	Compared with Nos. 20 and 21 they show less deterioration because the seeds are comparatively new. Value Rs. 270.
27	Broach Hagari	Compared with No. 24 it is slightly longer in length of fibre and we value it Rs. 5 higher, say Rs. 285.

In forwarding this report I ventured to suggest the following recommendations :—

Nandyal (1 to 9 of my numbers).—All are worth experimenting with on a large scale to test their actual production and ginning percentage. They are 10 to 20 per cent.

superior to Kumpta and 30 to 40 per cent. to Westerns, so that a decided step in improvement has already been taken. Nos. 2, 6, 7 should be abandoned on account of their low percentage.

Hagari.—The value of the selections Nos. 12 to 16 is equal to that of the best class of Westerns. Those which show a further falling off in the ginning percentage this year should be given up. No. 17 might be given another chance, but a low price accompanied by a falling percentage is against 18.

Of No. 23, the black seeded cotton, Messrs. Tata, Sons say it is the best indigenous cotton (of these samples) both in colour and length of fibre. The ginning percentage is so low that the production would have to be high before the crop would pay to grow. As its quality is so highly spoken of, experiments with it should be persevered in as the percentage might improve.

Looking at the results of experiments conducted for several years with 3 types of Guzerat cottons, it is obvious that only Broach should be maintained and *Kanvi* and *Lalio* abandoned as they are of an inferior type. The result of the acclimatization of these is that they have adopted the characteristics of their new locality. Cotton from recently introduced seed is superior in price and ginning percentage, but without figures of production on a field scale it is impossible to say further than this.

But, granting that these are also superior, it would be the safest policy to bring in annually a large proportion—say 30 per cent.—of freshly introduced Broach seed into the cotton districts supplied by the seed farm at Hagari. We recommend that this seed should be obtained from the Experimental Farm at Surat.

The long growing season of the Guzerat varieties is perhaps the most vital objection to their introduction unless it be found possible to sow earlier as is done in the case of Broach cotton in the Dharwar District.

Koilpatti Farm.—The following are the valuations furnished by Messrs. Tata, Sons & Co. and the Chamber of Commerce, Bombay :—

Valuations.

Serial No.	Corresponding pedigree No. of the Koilpatti Farm during 1911-12.	Valuation by Messrs. Tata, Sons & Co., Bombay, on 19th December 1912.	Valuation by the Chamber of Commerce, Bombay, 8th February 1913.
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Karunganni A type—Single Plant Selection.

1	24	Out of the 17 samples examined, we find Nos. 1, 11, 12, 13, 14 and 16 superior to the average type of F. G. F. Tinnevelly cotton, especially in length of staple. We value them Rs. 25 higher than the price of F. G. F. Tinnevelly. The rest of the samples show a slight superiority over the average F. G. F. Tinnevelly and we value them Rs. 10 higher.	Samples 11 and 12 considerably superior to any other. Value about Rs. 370 per candy of 784 lbs. (if available in quantities) with fully good fair Tinnevelly at Rs. 328.
2	2		Nos. 13 and 14 second best, about Rs. 30 per 784 lbs. over fully good fair Tinnevelly.
3	1		
4	22		Nos. 1, 6 and 3. Value about Rs. 25 above fully good fair Tinnevelly.
5	17		
6	16		Nos. 2, 4, 5, 7, 8, 9 and 10. Value about Rs. 15 above fully good fair Tinnevelly.
7	15		
8	3		Nos. 15, 16 and 17 somewhat better in staple than the 2-10 series, but lower in class. Value about Rs. 10 above fully good fair Tinnevelly.
9	6		
10	5		
11	8		
12	7		
13	14		
14	13		
15	12		
16	11		
17	10		

Karunganni C type—Single Plant Selection.

1	1	The colour of these samples is not so bright as that of A type. It shows a tinge of red and is creamy white. In appearance, feel and length of staple, it is equal to average F. G. F. Tinnevelly and we value it at the price of F. G. F. Tinnevelly cotton.	All samples have a reddish tinge. Nos. 2, 3 and 5 are somewhat better in staple than fully good fair Tinnevelly and perhaps slightly higher in value. Remaining samples are of about the same value as fully good fair Tinnevelly. All samples show a rather rough fibre.
2	2		
3	3		
4	5		
5	6		
6	7		
7	8		

Valuations—contd.

Serial No.	Corresponding pedigree No. of the Koilpatti Farm during 1911-12.	Valuation by Messrs. Tata, Sons & Co., Bombay, on 19th December 1912.	Valuation by the Chamber of Commerce, Bombay, 8th February 1913.
<i>Karunganni A-C types—Under Field Scale.</i>			
1	1 F. P.	Except Nos. 2 and 3, the other six samples are equal to ordinary F. G. F. Tinnevelly and we value them at the price of that cotton. Nos. 2 and 3 are decidedly better in appearance and length of staple and may be valued at Rs. 15 over the price of average F. G. F. Tinnevelly cotton.	We consider Nos. 6 and 8 the best on account of staple and value such cotton about Rs. 15 higher than fully good fair Tinnevelly. Nos. 4 and 7 we consider second best and about Rs. 10 higher than fully good fair Tinnevelly. Nos. 2, 3 and 5 are about equal to fully good fair Tinnevelly and No. 1 not up to fully good fair Tinnevelly.
2	1 F. C.		
3	1 F. C.		
4	2 F. P.		
5	2 F. C.		
6	3 F. C.		
7	3 F. P.		
8	4 F. P.		
		<i>Basis.</i> —F. G. F. Tinnevelly equal to Rs. 328 per candy of 784 lbs. laid down in Bombay.	<i>Basis.</i> —Fine Broach M. Gd. Rs. 330. Good Kumpta M. Gd. Rs. 335. Fine Navasari M. Gd. Rs. 350.

The work of this station is confined to the improvement of *Karunganni* which previously existed as a mixture in the fields with an inferior variety called *Uppam*. The valuations show that considerable progress has been made. My assistant, Mr. D. P. Mankad, who visited this locality last year, says that in Duraswamipura village, about 4 miles from the Koilpatti Farm, cultivators have been growing a *neglectum* mixture which they call *Pulichchi paratti*. It is very important that the Department should take steps to check the introduction of such inferior varieties into this tract. The cultivators consider that the chief advantage of *Uppam* as compared with *Karunganni* lies in its shorter growing season, greater uniformity in ripening and superior hardiness.

Mr. Mankad has the following remarks on the cultivation of Cambodia cotton in Madras and these throw light on the causes which have led to the loss of reputation of this staple.

“ During the past few years the cultivation of Cambodia in the Madras Presidency flourished remarkably well in garden soils commanded by well irrigation. The lands then were well ploughed and the cultivators paid special attention to its cultivation, including manuring, etc. Now-a-days, however, any land is put out under this cotton and the methods of cultivation are rough and ready.

“ All the fields under Cambodia were found to contain plants of *Uppam* and *Karunganni* types to a considerable extent. It is this admixture of inferior Madras cottons which has been noticed by the trade and has rendered Madras Cambodia unsaleable as high class cotton. This admixture not only tells upon the ginning percentage, but also on the quality of the fibre which is of vital importance in the trade.

“ If some steps are not immediately taken to keep Cambodia *kapas* perfectly pure from local *kapas*, the present state of affairs will become still worse and this high grade cotton will fall permanently to the level of the local cottons in price.”

(f) *Bombay*.—*Dharwar and Gadag Experimental Stations*.—I supplied the following report on my inspection of the stations :—

1. *Dharwar Farm, 14th March 1913.*

- (1) There is a series of nine generations of Broach cotton showing a continuous deterioration to the Kumpta or local type. We agreed that the most practical method of maintaining the Broach character would be to renew the seed over the whole area once every three years.
- (2) In *Kumpta* selections, quantity should not be lost sight of. A particularly good strain seems to be grown in the Sangli State and seed from this locality should be tried against that locally produced.
- (3) *Cambodia* is not suitable for Dharwar conditions.
- (4) Cross between *Kumpta* and *Comilla*.—If possible, plants with the *Comilla* leaf should be selected

so that, in the event of this strain coming into cultivation, mixtures with local Kumpta could be easily detected.

- (5) The crosses between Soft Peruvian and Cambodia are promising. It is recommended that first selections should be reduced to one plant of each type.
- (6) *Selected Kumpta*.—The seed of this has not yet been distributed. An attempt should be made to ascertain the actual opinion of the cultivators on its merits. If they consider it superior they should show their appreciation by offering a higher rate for the seed.
- (7) *68E—Cambodia (plant 24, selection)*.—The plants are vigorous but the bolls are small and do not open properly. It is recommended to continue the trial of this at Gadag where conditions are more suitable for Cambodia.
- (8) The results of manurial experiments are still inconclusive.
- (9) *Wind-break experiments*.—The *Shevri* will probably last for three or four years without renewal.
- (10) There is general dissatisfaction regarding the quality of the introduced Navasari seed. It would be as well to depute a special officer to select seed on the spot, and the extra expense incurred could be met by a proportional enhancement in the price of seeds sold to cultivators. Your own suggestion to obtain seed of the superior strain distributed from Surat is probably a still better way out of the difficulty.

2. Gadag Farm, 15th March 1913.

- (1) This farm might be restricted to trials with American types of cotton. One-half of the seed of each of the selected plants of Cambodia-Soft Peruvian should be tried here.

- (2) It would simplify matters a great deal if the whole of the Cambodia was treated as being essentially one variety so that material for selection could be taken this year over the whole experimental area. This year's field results are rather disappointing and disquieting, but it is to be hoped that the cultivators will agree to give Cambodia a further trial and they ought to be warned that fraudulent mixing with Dharwar American will not go to serve their best interests in the market.
- (3) There are two forms of Dharwar American mixed in the fields. I would suggest that one plot of each should be grown for comparison. I should also like to have a sample of the cotton from each for expert valuation this season. I am satisfied in my own mind that the alleged deterioration of Dharwar American is caused by the mixture of a superior and inferior type.
- (4) Two of the crosses appear to be promising : Christopher and Christopher, and Culpepper and Christopher. The cottons of these should be submitted for valuation.
- (5) The histories of the various cottons under trial in the Southern Mahratta Country have been carefully and intelligently kept up and they now possess a distinctly appreciable value.

Valuations furnished by Messrs. Tata, Sons & Co. on the samples from Dharwar and Gadag Farms, on the 29th May 1913.

Serial No.	REMARKS.
<i>Samples of the Dharwar Farm, 1911-12 crop.</i>	
1	Kumpta ordinary. Value Rs. 290.
2	Kumpta Cross. This is an excellent cotton and shows much improvement in colour, staple and strength of fibre. In spinning quality we consider this cotton in no way inferior to indigenous Navasari cotton, only it lacks the soft silky feel and the creamy lustre of Navasari, hence we value it at Rs. 325. Of the five samples this is by far the best.

Valuations furnished by Messrs. Tata, Sons & Co. on the samples from Dharwar and Gadag Farms, on the 29th May 1913—contd.

Serial No.	REMARKS.
3	Broach (new seed from Navasari). Grown on Dharwar Farm, this cotton has picked up some of the characteristics of the soil and climate. Being Navasari seed it is superior to Sawginned Dharwar and Kumpta, but it has deteriorated in the Dharwar soil from its original quality as grown in Navasari. This is owing, perhaps, to the high altitude and dry climate of Dharwar. We have marked that whenever Navasari has been removed further away from the sea it shows deterioration. We value this sample at Rs. 315.
4	Cambodia. Though superior to Kumpta and Dharwar it has lost its native lustre and strength of fibre and has deteriorated considerably on the Dharwar Farm. Value Rs. 300.
5	Kumpta x Ghogari. This cross is far superior to ordinary Kumpta, but it is inferior to No. 2 Cross. Value Rs. 315.
6	Kumpta ordinary. Slightly inferior to No. 1. Value Rs. 288.
7	Kumpta selected for quality. It shows improvement in colour over No. 6. Value Rs. 298.
8	Kumpta selected for quantity. It is inferior to ordinary Kumpta. Value Rs. 285.
9	Kumpta Cross. It shows improvement over Nos. 6, 7 and 8, but compared with No. 2, it shows considerable falling off in colour and length of staple. Value Rs. 305.
10	Broach old seed. It has lost all its characteristics of Broach and has deteriorated to the level of Kumpta, and we value it at Rs. 300. There can be no comparison between this and No. 3, as the latter retains its character of Broach cotton, while No. 10 has entirely lost it.
11	Kumpta x Ghogari. Compared with No. 5 it shows a slight falling off. This we attribute to No. 5, being crossed on the Surat and No. 11 on the Dharwar Farm. Value Rs. 310.
<i>Samples from Gadag Farm, 1911-12 crop.</i>	
12 to 17	Samples from Gadag Farm. These 6 samples are more or less alike and of the characteristic of Sawginned Dharwar cotton. No. 14 being machine ginned (not sawginned), shows better length of fibre over the rest which are sawginned. All the 6 samples show variations. We value Nos. 14 and 16 at Rs. 300 and the rest at Rs. 295.
18 and 19	Of the two, No. 18 is better in length of staple; both the samples are superior to Kumpta or Dharwar ordinary. We value No. 18 at Rs. 305 and No. 19 at Rs. 295.
	(No. 18, Dharwar American type; and No. 19, New Orleans type of 1912-13 crop.)

Rs.

Basis of prices—

Good Sawginned Dharwar	288
Good Kumpta Ginned	290
Fine Broach Ginned	290
Good Northern Ginned	295
Good Cambodia Ginned	320
Fine Navasari Ginned	340

In forwarding this report I submitted the following supplementary observations :—

Dharwar Farm.—We agreed that in the series of 9 generations of Broach cotton it showed a continuous deterioration to the Kumpta or the local type and that the most practical method of maintaining the Broach character would be to renew the seed over the whole area once every three years. Messrs. Tata state as follows regarding a sample of cotton grown from Broach new seed from Navasari :—

“ This cotton has picked up some of the characteristics of the soil and the climate. Being Navasari seed it is superior to sawginned Dharwar and Kumpta, but it has deteriorated in the Dharwar soil from its original quality as grown in Navasari. This is owing, perhaps, to the high altitude and dry climate of Dharwar. We have marked that whenever Navasari has been removed further away from the sea it shows deterioration. We value this sample at Rs. 315 against Navasari Rs. 340.”

On a sample of cotton of Broach cotton from old seed (acclimatized seed) the remark is as follows :—

“ It has lost all its characteristics of Broach and has deteriorated to the level of Kumpta and we value it at Rs. 300. There can be no comparison between this and Broach cotton from new seed as the latter retains its character of Broach cotton, while the former has entirely lost it. This has been valued at Rs. 300 while Broach from new seed valued at Rs. 315 and original Navasari at Rs. 340.”

In the Kumpta selections we agreed that quantity should not be lost sight of. The sample from a plot grown with this object in view was valued at Rs. 285 while a sample of ordinary Kumpta was valued at Rs. 288 and another at Rs. 290; while a sample of Kumpta selected for quality was valued at Rs. 298; while of the special selections the

Kumpta Cross No. 1339 from one plot was valued at Rs. 325 and from another at Rs. 305, the market price of the good Kumpta ginned of the day being Rs. 290.

Of the Kumpta Cross, which is the best cotton on the Dharwar Farm, Messrs. Tata have the following remarks :—

“ This is an excellent cotton and shows much improvement in colour, staple and strength of fibre. In spinning quality we consider this cotton in no way inferior to indigenous Navasari cotton; only it lacks the soft silky feel and the creamy lustre of Navasari, hence we value it at Rs. 325.”

Of the second sample of the Kumpta Cross cotton they say that when compared with No. 1 it shows considerable falling off in colour and length of staple; the valuation is Rs. 305. The discrepancy in the quality is puzzling, but it may be capable of explanation.

Anyhow, valuations indicate that Kumpta Cross 1339 should be persevered with.

We decided that Cambodia is not suitable for Dharwar conditions and Messrs. Tata's opinion confirms this as they say :—

“ That though superior to Kumpta and Dharwar it has lost its native lustre and strength of fibre and has deteriorated considerably on the Dharwar Farm. It is valued at Rs. 300 against good Cambodia ginned Rs. 320.”

Of the Kumpta and the Ghogari Crosses 1027A and 1364, Messrs. Tata say of the former that it is far superior to ordinary Kumpta but it is inferior to the Kumpta Cross 1339 and that the latter shows a slight falling off. The first is valued at Rs. 315 and the second at Rs. 310.

Gadag Farm.—We considered that it will simplify matters a great deal if the whole of Cambodia was treated as being essentially one variety, and this decision is con-

firmed by the remarks on the six samples made by Messrs. Tata :—

“ That they were all more or less alike and of the characteristics of sawginned Dharwar cotton. The machine ginned sample shows better length of fibre over the rest which are sawginned. Two samples, Cambodia 102E and 67E, valued at Rs. 300 and the rest at Rs. 295 against Rs. 288 of good sawginned Dharwar and Rs. 320 good Cambodia ginned.”

In conclusion, with reference to my statement that alleged deterioration of the Dharwar American cotton is caused by the mixture of an Upland and the New Orleans type of cotton, it seems that I am so far correct as Messrs. Tata value the former at Rs. 305 and the latter at Rs. 295. I hope that this year one full plot under each will be grown for comparison.

As regards the Cambodia cotton experiments which have been conducted in this tract, 3,500 acres were sown during the past year. Continuous rain during the seedling stage caused so much wilt that many plants died. The shoot borer would not allow the plants to grow until very late. The continuous east winds for six months (which is considered bad for cotton) caused many flower buds to drop and the soil moisture was quickly evaporated. The result of these adverse circumstances was that the yield was lowered by 40 per cent., that is, the yield should have been 350 to 375 lbs. per acre instead of about 210 lbs. The ginning percentage varied from 38 to 32·5 with a general average of 36·1.

The prices per *Naga* of 1,344 lbs. realized at the auction were Rs. 185 to Rs. 161, the quotations for Dharwar American and Kumpta on the same day being respectively Rs. 140 and Rs. 139 to Rs. 141.

Surat.—A set of samples from this station shows that the product has now become so uniform that there is only a difference of Rs. 13 per candy between the highest and lowest quotations,

Dohad.—Samples of *Bhuri* and Cambodia produced at this station were valued at Rs. 310, fine Broach of the day standing at Rs. 300. *Bhuri* yielded 1,104 lbs. seed cotton per acre, ginning percentage 32·8; Cambodia 876 lbs. per acre, ginning percentage 32·3. Early sown *Varkadi* yielded at the rate of 884 lbs. per acre, while the same late sown was cut off by frost. It will be seen, however, from the following remarks, that there is small prospect of extension of cotton cultivation in the Panch Mahals. The soils in which *Bhuri* and Cambodia were tried grow wheat in these parts. Panch Mahals does not grow much cotton, a portion from Derol to Pawagarh grows *Kanvi* and *Ghogari*, the latter predominating. Cottons come to maturity earlier in these parts owing to the stony nature of the soil. Kalol Taluka grows *Rozi* and *Kanvi* to a certain extent. Beyond this the cultivation of cotton practically ceases. It does not seem that the cultivation of cotton will spread, as the soil capable of producing cotton will yield two crops, namely, maize and gram, or groundnut and wheat.

Nadiad.—I submitted the following remarks on the samples sent by this station :—

Judging from the valuations of the cottons from Nadiad, Cambodia is easily first, but as this is a new introduction, some time must elapse before it can be confidently recommended for general cultivation under irrigation.

The claims of *Lalio* cotton indigenous to the tract should be carefully tested. It is highly probable that ultimately it would be found the most profitable to grow.

Bourbon is valued highly but its perennial nature is objectionable. Experiments made years ago certainly proved that it is not a reliable plant to depend upon. Mr. Spence's attempts at its cultivation on a large scale at Deesa and Jamnagar both signally failed and no one reports even moderate success with it. For all practical purposes the cotton experiments at Nadiad could be confined to trials with Cambodia and *Lalio*.

Valuations by Messrs. Tata, Sons & Co. on the six samples of Nadiad on 23rd June 1913.

Serial No.	Name of variety.	REMARKS.
1	Cambodia	Nadiad Farm appears to suit this cotton as all the characteristics of Cambodia are maintained. We value it at Rs. 320. We recommend that special attention should be given to its cultivation at Nadiad.
2	Bhuri	This cotton is after the style of Ghat Berars and we class it equal to Kirkeli. Value Rs. 300.
3	Lalio	The Nadiad soil suits the seed as the sample under inspection equals the best cotton grown in Bawla (Guzerat District). Value Rs. 290.
4	10 T. Bourbon	It is a very nice cotton, silky and long stapled, and is equal to some low grades of Egyptian cotton. We value it at Rs. 350.
5	Vardiadi	This cotton has entirely changed its character and looks more like short staple Rajputana Bengal than like Khanderesh. Value Rs. 250.
6	Comilla x Bani	This cross shows the roughness and feel of Comilla (Assam) combined with the staple of Bani. It can be compared to Fine Warora. Value Rs. 300.

Basis of value—

	Rs.
Low Egyptian	350
Fine Surat	330
Kirkeli	310
Fine Warora	300
„ Ghat (Chikli)	278
„ Bengal	245
„ Navasari	345
Cambodia	320
Fine Broach	305
„ Guzerat	290
„ Akola	268

At Bawla in the Ahmedabad District, Mr. Mankad reported as follows :—

“ Four persons tested Cambodia on the following areas :—

Area in acres.	Total outturn in lbs.	Outturn per acre.	Valuation realised per 40 lbs. kapas.	REMARKS.
			Rs. A. P.	
0.24	680	1,133	6 6 0	Irrigated five times.
0.30	1,000	1,333	6 5 3	Irrigated three times.
1.0	800	800	6 4 0	Irrigated two times.
1.0	400	400	6 6 0	White-ants damaged crops. No watering given.

All the Cambodia was purchased by one man who gave ordinarily four annas more per maund over the local cotton *Lalio*.”

There is a tendency for the cultivators to extend the cultivation of Cambodia next year. I learn that cultivators are willing to pay high rates for the seed, as much as Rs. 5 for 40 lbs. seed. It was also said that some seed was sold at Rs. 8 a maund of 40 lbs.

With regard to the results of *Lalio*, it must be said that, under the same condition (irrigation), one acre and seven gunthas yielded 2,000 lbs. *kapas*, that is, 1,700 lbs. per acre. The possibilities of *Lalio* should be very carefully tested as present indications point to its being quite able to hold its own ground against Cambodia.

The cultivators at Bawla are, however, in favour of their local cotton—*Lalio*, and think that though the results are promising the new cotton, Cambodia, is a much more delicate variety than their local cotton. They are also aware of the fact that it would be susceptible to frost and insect pests.

To conclude with Guzerat, I quote the general remarks submitted to the Director.

“ 1. *Surat*.—There are three strains maintained for seed distribution. The Syndicate have agreed to buy the produce of these at 5 per cent. over local prices and I am informed that private firms are independently offering 6

per cent. As this is the second season in which the improved cottons will be on the market it is gratifying to learn that the traders appreciate the value of the selections.

" 2. *Broach*.—The tendency of the cultivators in this tract is to mix *Ghogari* with Broach in order to help out the ginning percentage of the latter. Some of the lighter soils might be devoted to the culture of pure *Ghogari*, but this point will be the subject of further enquiry. Broach cotton seed, obtained from Surat, was distributed by the local Agricultural Association. The members of this body have apparently not supervised the tests so closely as they require and they are only now invoking the aid of the Agricultural Department, as they foresee the difficulty of disposing of their produce on favourable terms without some support in the shape of an official guarantee. They may find a way out, but in the event of an expansion in their task of cotton seed distribution it would be as well to warn the Association to be guided by the advice of your Department. As you remarked, these Associations under proper control may become valuable agencies for the distribution and maintenance of selected crops. The Association ought soon to be strong enough to employ an expert staff to assist them in their operations. Wilt is said to be increasing in this district and is probably due to the continuous cropping of the land under cotton. I understand that the Imperial Mycologist has taken up the investigation of this disease.

" 3. *Nadiad*.—Our long-cherished hope that some tree cottons could be profitably grown in the Kaira District has been dispelled.

Bourbon is too uncertain, as it is likely to do badly in wet years and, being a perennial crop, the land on which it grows, under the careless methods of the cultivators, becomes a jungle of weeds. It also acts as an agent in the propagation of boll worm. Cambodia and *Bhuri* both promise very well, if slight irrigation (which is available in many places) can be given them at the start. The claims of the local *Lalio* are strong and are being seriously considered.

" 4. *Baroda*.—The experiments here are identical with those at Nadiad. There is a possibility that in this tract *Bhuri* can be grown as a dry crop. I pointed out on the spot that the Cambodia grown from Madras seed was contaminated with an admixture of *Uppam* and *Karunganni*. The plots at Nadiad had been of course purified by the Superintendent and I suggested that you instruct your Department in the Southern Mahratta Country to see that their fields were also purged of this annoying mixture.

" 5. *Dohad*.—Cambodia, *Bhuri* and *Varhadi* (*roseum*) were doing exceedingly well, but it seems waste of time to distribute good cotton seed amongst such bad cultivators. However, the good example shown them at the Dohad Farm may show fruit in due time."

The Chief Karbhari, Rajkot State, sent in the following report on the crops resulting from 50 lbs. *Varhadi* and 20 lbs. Cambodia seed, which were sent to him for trial. The outturn of *Varhadi kapas* was $17\frac{1}{2}$ maunds in 2 *bighas* of the palace garden experimented upon, or in other words it was 21 maunds and 35 lbs. per acre (875 lbs. *kapas* per acre); whereas that of Cambodia *kapas* was $2\frac{1}{4}$ maunds in $\frac{1}{2}$ acre of it, *i.e.*, $4\frac{1}{2}$ maunds per acre, a maund being equal to 40 lbs.

The ginning percentage eventuated in 40 per cent. of *Varhadi* and 35 per cent. of Cambodia cotton.

The result is more in favour of *Varhadi* than Cambodia which does not, it seems, suit the soil. The *Varhadi* is being grown on a larger scale this season.

Evaluation by Messrs. Tata, Sons & Co., Bombay, on the samples from Rajkot on 23rd June 1913.

Serial No.	Name of variety.	REMARKS.
1	Varhadi .	This cotton has preserved all its characteristics of Akola except the staple which shows deterioration. Value Rs. 260.
2	Cambodia .	The cotton has deteriorated all round and looks more like Ghat cotton (Chikli). Value Rs. 270.

Basis of valuation—

	Rs.
Fine Warora	300
„ Ghat (Chikli)	278
„ Akola	268
Mathio	250

Dhulia.—Messrs. Tata were good enough to supply the following valuations and remarks on the samples sent from this station (10th April 1913) :—

Serial No.	Name of variety.	REMARKS.
1	Rosea . . .	It has all the characteristics of Fine Khandesh cotton, only it is slightly better in staple than the usual run of Khandesh cotton for which we value it Rs. 8 higher than Fine Khandesh (basis Fine Khandesh, Rs. 272), say Rs. 280 per candy.
2	Cutchica	No improvement, practically Fine Khandesh. Value Rs. 272, being the basis of Fine Khandesh.
3	Vera . . .	It has lost its Khandesh characteristics and has the colour, staple and feel of Bani Berars. Taking Rs. 320 as the basis of Bani Akola, we value it the same price, Rs. 320 per candy.
4	Malvensis .	It is like No. 1. The feel, however, is better, which advantage is counterbalanced by the staple being slightly inferior. We value it at Rs. 5 more than Fine Khandesh (basis Rs. 272), say Rs. 277 per candy.
5	Khandesh Jari	It is ordinary fully Good Khandesh cotton. Value Rs. 262 (same as fully Good Khandesh, basis of Rs. 262).
6	Bani . . .	It is equal to No. 3 and of the same value, say Rs. 320 per candy.
7	Comilla . .	In the Khandesh soil and climate it has slightly lost its native harshness; in all other respects it remains Assam cotton. We value it at Rs. 275 per candy, say Rs. 15 better than Superfine Bengal (basis Superfine Bengal, Rs. 260).

Valuations.—All samples received were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation, and cordial acknowledgment is due to them for their kindness and promptitude in giving opinions on cottons whenever submitted to them.

Samples of the Koilpatti Agricultural Station were reported upon by the Bombay Chamber of Commerce to whom thanks are also due.

III.—PROGRAMME OF WORK FOR 1913-14.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

(2) By special invitation of the Departments of Agriculture of the United Provinces of Agra and Oudh, Bombay, and North-West Frontier Province to report on the work done in the way of cotton improvement in those provinces.

(3) The question of the distribution of seeds of promising varieties will be further discussed with the proper authorities in the United Provinces, Central Provinces, Bombay and the Punjab.

(4) The study of the behaviour of *Bhuri* and Cambodia and other such cottons in non-cotton-producing tracts will be continued.

(5) An enquiry on the manurial requirement of cotton will be continued.

(6) Researches on the botany of cotton will be continued.

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